

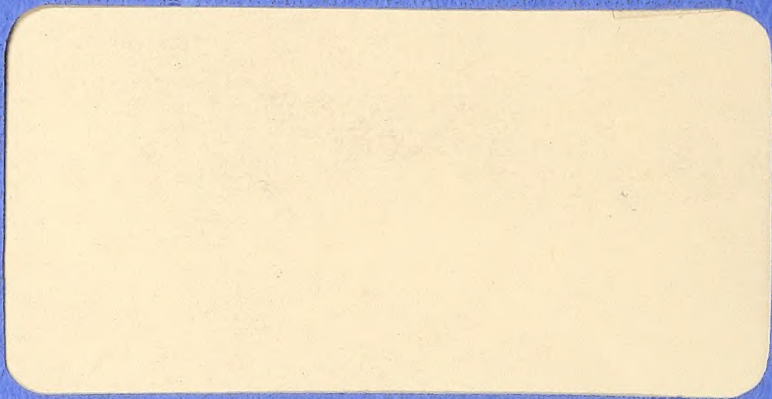
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FINAL REPORT

EFFECTS OF FREEZING RATE, STORAGE TEMPERATURE,
TEMPERATURE ABUSE AND STORAGE TIME ON SENSORY,
CHEMICAL, INSTRON AND YIELD PROPERTIES
OF GROUND BEEF PATTIES WITH SOY



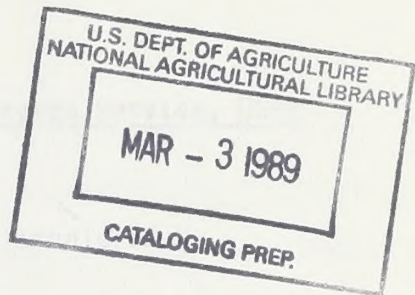
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TEMPERATURE ABUSE AND STORAGE TIME ON SENSORY,
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OF GROUND BEEF PATTIES WITH SOY

PREPARED FOR THE

U.S. ARMY NATICK RESEARCH AND DEVELOPMENT LABORATORIES
NATICK, MASSACHUSETTS 01760

AND THE

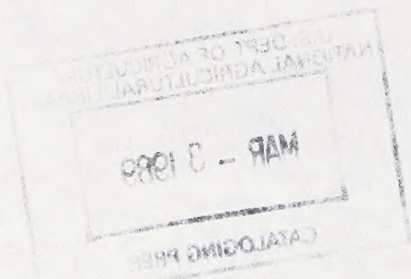
FOOD QUALITY ASSURANCE BRANCH
MARKET RESEARCH AND DEVELOPMENT DIVISION
AMS, USDA

BY THE

MEAT SCIENCE RESEARCH LABORATORY
AGRICULTURE RESEARCH SERVICE
U.S. DEPARTMENT OF AGRICULTURE
BELTSVILLE, MARYLAND 20705

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FEBRUARY 1987



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OVERALL SUMMARY AND CONCLUSIONS

The imposed sources of variation in this study seemed to affect the attributes studied more for patties with soy than bulk ground beef with soy or beef roasts. This is probably due to: (1) the product (patties) being much smaller and thinner, and (2) the amount of packaging being much less. Advancements in storage time and the use of +20°F often were responsible for changes in product characteristics, however freezing rate did exert some influence, especially for tenderness properties.

Following six months of storage, more darkness in patty pigmentation could be observed for patties stored at +20°F. Much more surface discoloration was noted on patties stored at +20°F vs the other storage temperatures. After twelve months of storage, the use of 0°F storage temperature produced more discoloration than -10°F. The use of +20°F storage, longer storage and the 0°F in 96 hour freezing rate all accelerated the presence of off-odor. More freezer burn was detected with longer storage and +20°F storage.

The use of +20°F especially increased TBA values. Product from the 0°F in 96 hour rate began an increase in TBA values early in storage, while up to 18 months of storage was required for the other freezing rates to show major TBA increases. Broiled ground beef flavor gradually decreased with time. Just the process of freezing increased the detectability of rancid flavor for the slower rates of freezing. Most of the rancid flavor was associated with +20°F storage. While the incidence of rancidity was high, there really wasn't an increase between 6 and 24 months of storage. Juiciness decreased slightly with storage.

Probably the most interesting finding related to this product were those related to freezing rate and sensory determined tenderness. The

slower the freezing rate, the less tender the patties. This difference was detected well out in the storage. Also, freezing in itself reduced tenderness, with obviously the larger reductions occurring for the 0°F in 72 and 96 hour rates. There was a slight tenderizing effect just due to storage. Instron measurements reflect somewhat the same findings for tenderness as the taste panel, although they were not as consistent. Actually, the 0°F in 96 hour rate produced similar values to the faster rates. Thus, it was more the 0°F in 72 hour rate which generated Instron values indicative of greater toughness. For most Instron measurements, the biggest change occurred just as a result of freezing, which produced a toughening effect. In contrast to the sensory panel data, longer storage produced Instron values indicative of a toughening effect. For modulus and fail energy, +20°F storage increased (toughening) values. Further study will be necessary to determine the cause of the toughening effect due to slower rates of freezing. This effect was also noted for patties processed without soy.

Losses in weight due to freezing were slightly more for 0°F in 96 hour frozen patties compared to the 0°F in 24 hour frozen patties. Storage reduced weight by about 1% between 6 and 24 months. The biggest change in cooking loss occurred just as a result of freezing which resulted in an approximately 9% reduction. Cooking losses gradually became less with advancement in storage time. During cooking, nonfrozen patties swelled, while frozen patties decreased in thickness. Also, freezing reduced the amount of moisture and slightly elevated the fat detected in cooked patties. With storage, 0°F in 96 hour patties had less moisture and subsequently more fat in cooked patties.

In conclusion, it does not appear that +20°F is a suitable storage temperature even for six months storage. In most cases -10°F was similar to 0°F either as an early or later storage temperature. With these two temperatures and the use of soy in the patties, in most cases acceptable products can still be obtained up to twelve months. In terms of freezing rate, there are some indications (color, off-color, TBA, tenderness, loss of moisture) that 0°F in 96 hours is not as suitable a freezing rate, especially when compared with 0°F in 24 hours.

INTRODUCTION

Freezing as a processing procedure is often a necessity for meat products that must undergo transcontinental and oceanic distribution or must be purchased far in advance of consumption due to supply, price and demand. These situations are frequently prevalent in USDA's purchase programs of ground beef for the school lunch program and DOD's procurement of meat products for military establishments. In order to maximize storage life, certain specifications regarding freezing rates, storage temperatures, packaging materials, raw material wholesomeness are applied.

One of the specifications required in the processing of meat products for government procurement deals with freezing rate. Prior to 1982, the requirement was that the product must be frozen to 10°F in 72 hr. Based on a variety of information sources, this requirement was changed in 1982 to 0°F in 72 hr, which reflects a faster rate of freezing. There were some representatives from industry who indicated that this faster freezing rate imposed hardships on their operations and placed them in non-competitive positions. However, there are others (processors and end-users) who maintain that faster freezing rates improve product quality.

In terms of defining what freezing rates were actually being used in industry, a nationwide survey of meat freezing operations was conducted. The survey indicated that a wide range in freezing rates was being practiced; some faster than the 0°F in 72 hr requirement, some slower. Thus, it was decided to evaluate for this project, four different freezing rates; 0°F in 24, 48, 72 and 96 hr. In preliminary studies, it was determined that wide ranges in time (often as much as 36-48 hr to reach 0°F) exist within a pallet load of meat in terms of when 0°F is achieved.

Thus, in order to achieve the uniformity in freezing rate required for this study, it was necessary to freeze product out of the boxes, spaced out on wire mesh racks.

Due to the lack of supportive literature to answer the effects of freezing rate on meat product characteristics, especially in conjunction with frozen storage time and temperature, this project was inaugurated. Four products (beef roasts, bulk ground beef with soy, ground beef patties with soy, ground beef patties without soy) were subjected to the above four freezing rates, two initial storage temperatures (0°F, -10°F), three final storage temperatures (0°F, -10°F, +20°F), temperature abuse of 4 hr at 85°F following 45 and 59 days of storage, and storage times of 0, 6, 9, 12, 18 and 24 months depending on the product. Evaluations included shelflife, microbial, sensory, instrumental texture, weight loss, chemical and cooking properties.

MATERIALS AND METHODS

Processing, Freezing and Storage

The overall project design is shown in Figure 1. Ground beef products were manufactured at a local meat processing establishment. Ground beef ingredients and product formulation conformed with USDA specification PPB 2120. Ground beef was extended with 20 percent rehydrated (2.5:1) soy protein concentrate (Procon 2060, A. E. Staley Co., Decatur, Illinois). Four batches (1100 pounds per batch) of the ground beef-soy product were processed on four different days, over a four-week period. The final fat content of each batch was adjusted to meet federal interim specification PPB 2120.

Following the addition of soy to the formulation, all batches were processed (Hollymatic 400) into 3-oz patties stacked 16 high, and boxed in 36 lb boxes. Boxes met USDA specification PPB 1163. The boxes were specifically constructed for ground beef patties, dimensions were 19"x13"x7". After boxing, product was shipped to University of Maryland research freezers within four hours of processing. At the University, stacks of patties were removed from boxes, divided into two stacks, eight high, and placed on wire racks, specifically constructed for the project, within the freezer. Copper constantin thermocouples, attached to temperature recording devices (Campbell Scientific 7, Digitec 1000) were inserted into the geometric centers of 12 patties placed in predetermined locations. An additional six thermocouples, distributed throughout the freezer, recorded ambient air temperature. The freezer thermostat was set at a temperature, predetermined from preliminary freezing trials, to achieve 0°F in 24, 48, 72 or 96 hours. Predetermined temperature adjustments were made at specific time intervals to achieve a given

Figure 1. Project design.

GBP W/ GSC
GBP W/O GSC
GBB W/ GSC
OVEN ROAST

0° F in 96 hrs.

0° F
in 72 hrs.

0° F
in 48 hr.

NO A B U S E

A B U S E

NO A B U S E

A B U S E

Diagram illustrating a four-stage shift register or data flow process:

- Stage 1: NO A B U S E
- Stage 2: A B U S E
- Stage 3: NO A B U S E
- Stage 4: A B U S E

Arrows indicate the flow of data from Stage 1 to Stage 2, and from Stage 2 to Stage 3, and from Stage 3 to Stage 4.

Diagram illustrating a two-bit adder circuit. The inputs are labeled A and B. Each input has a '0' line and a '1' line. The '0' lines are connected to a block labeled 'NO ABUSE', and the '1' lines are connected to a block labeled 'ABUSE'. The outputs of these blocks are connected to a 'SUM' output.

[illegible]

HEATS FREEZING PROJECT

MEAT SCIENCE RESEARCH LABORATORY

For the U.S. Army Natick Research and Development Laboratories

January 1983

(FIGURE 1)

KEY

CBP - Ground Beef Patties
CBB - Ground Beef Bulk
CSC - Granulated Soy Concentrate
ABUSE - At days 45 and 59
4 hrs. at 85°F

freezing rate. All thermocouple temperatures were monitored and recorded hourly throughout the freezing process.

After freezing, frozen patties were stacked 16 high, reboxed and placed in storage at 0° or -10°F. After 45 and 60 days of storage at these temperatures, one-half of the boxed product in each rate received temperature abuse (80°F for four hours). The boxed product was laid on pallets outside of the laboratory to simulate temperature abuse encountered in normal military distribution channels. The temperature abuse slightly thawed the product surface. On day 60 of frozen storage, all product (abused and nonabused) was randomly divided and placed into one of three final storage temperatures +20°F, 0°F or -10°F for 6, 9, 12, 18 or 24 months.

Sample Selection

Two boxes of patties representing each freezing rate-initial-final temperature treatment were selected for evaluation at each storage interval.

Microbiological Analysis

Three frozen patties were aseptically selected from each box (top patties of a stack were always excluded). Individual patties were placed in sterile petri dishes prior to analysis. Representative samples (9.3 g) from each of the three patties were combined into a composite sample (25 g) representing each box. The 25 g sample was diluted with 225 ml of peptone water (1.0%, Difco) and blended two minutes in a stomacher (Seward No. 400). Serial dilutions (10^{-3} - 10^{-5}) were prepared from the blended sample and then plated in duplicate in Tryptic soy agar (Difco). Total aerobic plate counts were made after 48 and 72 hours of incubation at 23°C.

Table 1. Microbiological Procedures

Quantitative Determinations	Media	Plating Technique	Incubation	Confirmatory Tests
Aerobic mesophiles	Standard Methods Agar (PRL)	Pour Plates	35°C/18 hr	Gram stain
Aerobic psychrophiles	Standard Methods Agar (PRL)	Pour Plates	15°C/96 hr 4°C/10 days	Gram stain

Shelflife

A trained team of staff members evaluated frozen patties within the box for evidence of shelflife deterioration. Lean color and surface discoloration were evaluated on four patties randomly selected from the interior of patty stacks, while freezer burn was evaluated from top patties of four stacks. Off-odor was evaluated on the entire box. Shelflife characteristics and scoring systems are outlined in Table 2.

Cooking Methodology

Preliminary cooking trials established predetermined cooking times needed to achieve consistent degrees of doneness among cooked patties. Ground beef patties were cooked directly from the frozen state for a total of seven minutes on preheated electric griddles (Farberware #260 SP). All patties were cooked two minutes per side, then an additional three minutes with frequent turning, to avoid excessive browning. Cooked patties were gently blotted prior to weighing and cutting. Degree of doneness scores were evaluated immediately after cutting. All patties achieved a degree of doneness of 2 on an eight-point photographic scale (3 = very rare, 1 = very well done).

Percent Yield

Sixteen patties, randomly selected from each box were weighed just before and after freezing and after frozen storage. Both individual patty and complete stack weights were recorded. Following the cooking procedure, individual patty weights were recorded for cooked yield determination.

$$\% \text{ yield} = 100 - \frac{\text{frozen weight} - \text{cooked weight}}{\text{frozen weight}} \times 100$$

Table 2. Characteristics and scoring systems for shelflife evaluation

Surface Discoloration and Freezer Burn	Color of Lean ^a	Off Odor
7 = 0%	8 = light grayish red	4 = no off odor
6 = <10%	7 = very light cherry red	3 = slight off odor
5 = 11-25%	6 = moderately light cherry red	2 = moderate off odor
4 = 26-50%	5 = cherry red	1 = extreme off odor
3 = 51-75%	4 = slightly dark red	
2 = 76-90%	3 = moderately dark red	
1 = >90%	2 = dark red	
	1 = very dark red	
	0 = dark purplish black	

^aPhotographic scale adapted from Western Australian
beef carcass classification system

Sensory Evaluation

Four patties from each treatment were randomly selected for sensory analysis. An eight-member descriptive attribute panel was trained according to the procedures of Cross et al., (1978). Panelists received two warm pieces (1/3 of a patty) to evaluate for initial tenderness, final tenderness, juiciness, ground beef flavor intensity, presence of other flavors, connective tissue and mouth coating by means of an eight-point structured scale (Table 3). Eight = extremely tender, juicy, intense in flavor, lacking connective tissue and mouth coating; 1 = extremely tough, dry, bland, abundant in connective tissue and very pronounced mouth coating. Panelists met three times a week for two sessions per day. Each session consisted of four to six samples. Serving order of samples within a session was completely random. Panelists were instructed to eat melba toast and drink warm apple juice between samples and they received a ten-minute break between sessions.

Instron Analysis

Six patties per treatment were randomly selected and cooked according to established cooking procedures. Cooked patties were loosely covered and cooled to room temperature (25°C). Each patty was trimmed to a 6.0 cm long section than cut into four equal 3.0 cm² pieces. Each piece was sheared with a straight edge shear blade attached to an Instron Universal Testing Machine (Model 1122), equipped with a micro processor (Microcon II).

Configurational Measurements

Frozen and cooked patty thickness and diameter were recorded on all patties cooked for Instron analysis in order to express shear data as Newtons (expression of peak load in relation to square patty area being sheared) and to evaluate patty shrinkage following cooking.

Table 3. Meat Science Research Laboratory - Ground Reef Form

<u>TENDERNESS</u>		<u>JUICINESS</u>	<u>CONNECTIVE TISSUE AMOUNT</u>
8 - Extremely tender	8 - Extremely juicy	8 - None = 0%	
7 - Very tender	7 - Very juicy	7 - Practically none = 1-9%	
6 - Moderately tender	6 - Moderately juicy	6 - Traces = 10-19%	
5 - Slightly tender	5 - Slightly juicy	5 - Slight = 20-29%	
4 - Slightly tough	4 - Slightly dry	4 - Moderate = 30-39%	
3 - Moderately tough	3 - Moderately dry	3 - Slightly abundant = 40-49%	
2 - Very tough	2 - Very dry	2 - Moderately abundant = 50-59%	
1 - Extremely tough	1 - Extremely dry	1 - Abundant = 60%	
<u>REEF FLAVOR INTENSITY</u>		<u>DETECTABLE FLAVORS AND INTENSITY</u>	
8 - Extremely intense	(In the off-flavor column, first indicate the number of the flavor component and behind it the intensity using the 8-point intensity scale).	1. Sour	Initial tenderness -
7 - Very intense		2. Bitter	at 5 chews
6 - Moderately intense		3. Metallic	Final tenderness -
5 - Slightly intense		4. Sweet	at 15 chews
4 - Slightly bland		5. Rancid	Connective tissue -
3 - Moderately bland		6. Putrid	at the end of mastication
2 - Very bland		7. Salty	Juiciness -
1 - Extremely bland		8. Other	during the first 15 chews
<u>MOUTH COATING EFFECT</u>		Flavor intensity and other flavors - throughout	
8 -		Mouthcoating - following swallowing	
7 - Slight			
6 -			
5 - Moderate			
4 -			
3 - Pronounced			
2 -			
1 - Very pronounced			

Chemical Analyses

TRA

Three frozen patties were randomly selected from each box and allowed to thaw until just pliable prior to analysis. One 10 gram sample from the center of each patty was analyzed in duplicate according to the distillation procedure of Tarladgis et al. (1950).

Expressible Juice

Four frozen patties per box were selected, placed in zip lock bags and allowed to thaw 12 hours at 4°C. One hour before analysis, samples were allowed to warm up to 25°C. Expressible moisture was determined from one sample (400-600 mg), removed from the center of each patty, according to the procedure of Mierbecki and Deatherage (1953) with modification described by Briskey et al. (1959).

Percent Fat and Moisture - Raw

Twenty-five patties from each box were selected and ground three times through a 0.3 cm plate (Hobart 4612) in accordance with A.O.A.C. procedures (1980). Three, 5-gram samples were analyzed from each composite sample. Percent moisture was determined by weight loss following 2-12 hours of drying at 100°C in a vacuum oven (Precision 524). Percent fat was determined on the dried samples by weight loss following 16 hours of extraction with petroleum ether.

Cooked Fat and Moisture

Twenty-four patties were cooked according to procedures described previously for sensory, yield and Instron analyses. Cooked patties were covered tightly, cooled to room temperature (25°C), ground and analyzed according to procedures described for raw patties.

RESULTS AND DISCUSSION

Respective freezing rate curves for the ground beef patties with soy are shown in Figure 2. The 0°F in 48 hour drip was somewhat accelerated and actually had a temperature rise between 33 and 43 hours.

Frequencies of occurrence for the various colors on patties with soy are provided in the next series of tables. Before freezing, there were some differences in color scores just due to formulation (Table 4). Product manufactured for the 0°F in 72 hour rate had considerable slightly dark red light grayish red. After six months of storage, there was a tendency for more of the lighter colors (conversely less of the darker pigments) on temperature abused product compared to nonabused product (Table 5). Following six months of storage, the use of +20°F storage temperature produces more of the darker pigments, with this being more pronounced the slower the freezing rate (Table 6). Obviously, lighter colors were less apparent with the +20°F storage. Following twenty-four months of storage -10°F produced more cherry red color than 0°F final storage temperature (Table 7).

During storage (up to twenty-four months), the incidence of cherry red color became greater if the product had been stored at -10°F, while storage at just 0°F decreased the presence of this pigment over time (Table 8). Light grayish red color became much less observable following freezing and was variable in terms of frequency as associated with final storage temperature and storage time (Table 9).

General data regarding surface discoloration on patties (Table 10) indicates: (1) increased discoloration with advancements in storage time, (2) increased discoloration from using +20°F temperature, and (3) slightly increased rate of discoloration for patties frozen to 0°F in 96 hours.

Figure 3. Freezing curves to reach 0°F in 24, 48, 72 and 96 hours for ground beef patties with soy.

GROUND BEEF PATTIES WITH SOY

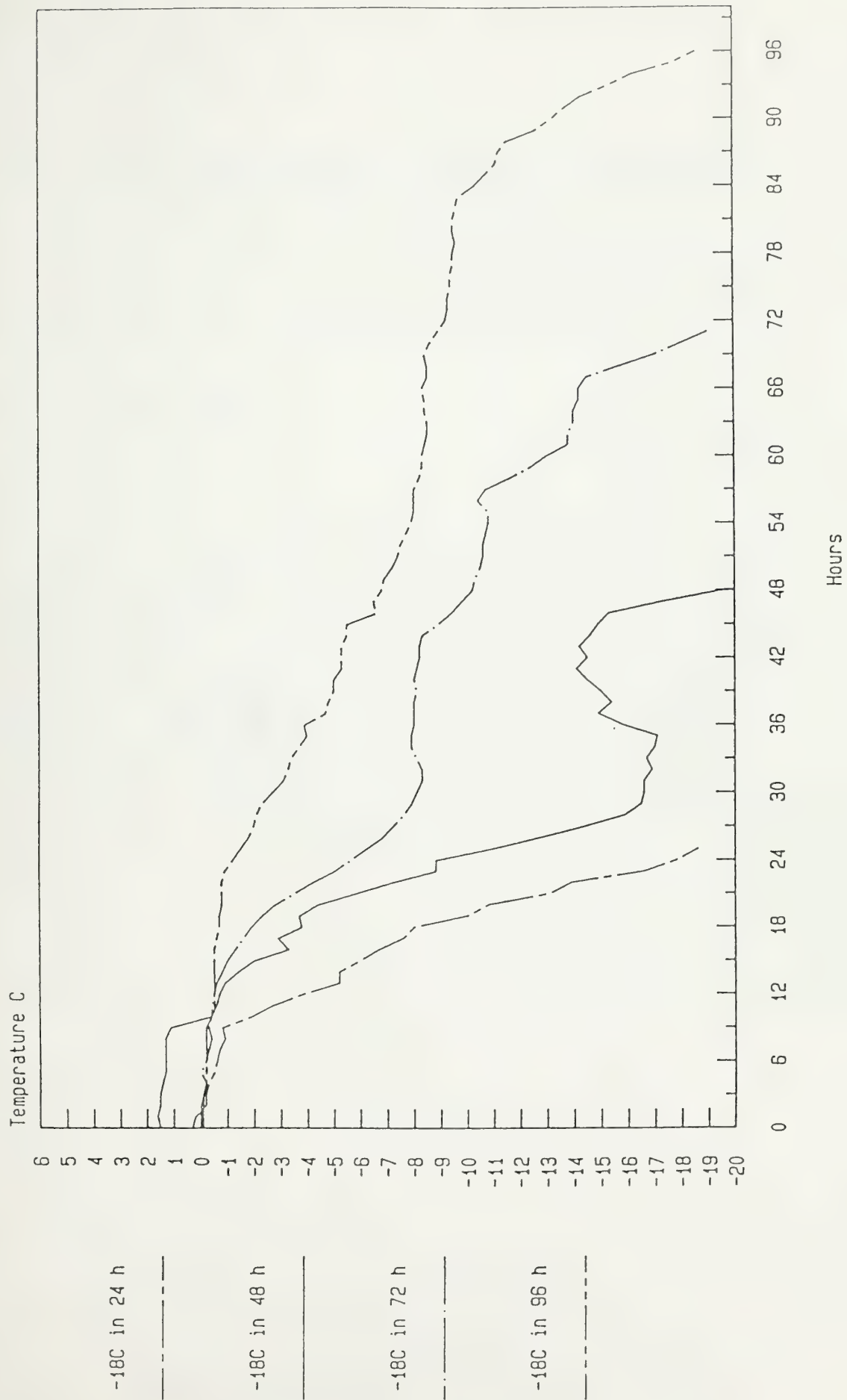


Table 4. Color scores assigned to ground beef patties with soy according to freezing rate just before freezing^a

Color	Freezing Rate, hrs to 0°F			
	24	48	72	96
Dark red	1.90	5.38	0.00	0.00
Moderately dark red	18.35	10.75	7.41	6.52
Slightly dark red	18.99	19.35	40.74	23.91
Cherry red	5.06	5.38	3.70	7.61
Moderately light cherry red	8.23	11.83	0.00	13.04
Very light cherry red	25.32	24.73	0.00	18.48
Light grayish red	22.15	22.58	48.15	30.43

Chi-square = 40.19 $P < .002$

^aValues are percentages of scores assigned within a freezing rate category.

Table 5 . Color scores assigned to ground beef patties with soy according to temperature abuse following six months storage^a

Color	Temperature Abuse	
	T	N
Very dark red	0.95	4.27
Dark red	13.84	24.09
Moderately dark red	18.77	18.90
Slightly dark red	17.91	17.99
Cherry red	4.45	3.05
Moderately light cherry red	20.47	19.82
Very light cherry red	18.01	11.59
Light grayish red	5.59	0.30

Chi-square = 55.67

^aValues are percentages of scores assigned within temperature abuse category. T = temperature abused, N = not temperature abused.

Table 6. Color scores assigned to ground beef patties with soy according to freezing rate and final storage temperature following six months storage.^a

Freezing rate, hrs to 0°F	Final storage temperature, °F	Color							
		Very dark red	Dark red	Moderately dark red	Slightly dark red	Cherry red	Moderately light cherry red	Very light cherry red	Light grayish red
24	-10	0.00	11.01	15.60	22.02	4.58	20.18	21.10	5.50
	0	0.91	13.64	16.36	19.09	7.27	20.91	19.09	2.73
	+20	0.60	19.05	19.05	17.26	2.96	22.62	17.26	1.19
48	-10	0.00	12.73	18.18	19.09	2.73	20.91	20.91	5.45
	0	1.79	14.29	16.96	18.75	5.36	19.64	17.80	5.30
	+20	3.23	20.00	23.23	15.48	1.94	23.23	12.26	0.65
72	-10	1.19	13.10	19.05	16.67	4.76	19.05	19.05	7.14
	0	0.00	4.60	17.24	18.39	9.20	20.69	20.69	9.20
	+20	2.78	22.22	20.56	18.33	5.19	16.33	12.22	1.67
96	-10	1.35	9.46	17.57	18.92	0.00	20.27	22.97	9.45
	0	0.00	5.75	16.25	12.50	6.25	21.25	20.00	15.00
	+20	7.02	31.58	21.05	18.42	2.63	15.79	3.51	0.00

Chi-square = 135.14, $P < 0.001$.
a values are percentages of scores assigned within freezing rate-final storage temperature combinations.

Table 7. Color scores assigned to ground beef patties with soy according to final storage temperature following twenty-four months storage^a

Color	Final storage temperature, °F	
	-10	0
Very dark red	0.36	1.51
Dark red	13.57	16.60
Moderately dark red	13.57	15.09
Slightly dark red	17.86	16.98
Cherry red	10.36	3.02
Moderately light cherry red	19.64	16.98
Very light cherry red	19.29	20.38
Light grayish red	5.36	9.43

Chi-square = 17.57 $P < .014$.

^aValues are percentages of scores assigned within a final storage temperature category.

Table 8. Incidence of cherry red color in ground beef patties with soy throughout storage and according to freezing rate and final storage temperature^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Before freezing	Immediately after freezing, 1 day	Evaluation Time				
				6 mo	9 mo	12 mo	18 mo	24 mo
24	--	5.06	5.00					
	-10			4.59	8.26	9.48	1.69	10.48
	0			7.27	6.84	7.56	1.82	1.10
	+20			2.98	--	--	--	--
48	--	5.38	2.33					
	-10			2.73	10.08	3.16	6.35	8.82
	0			5.36	7.83	6.93	1.82	2.13
	+20			1.94	--	--	--	--
72	--	3.70	2.99					
	-10			4.76	5.36	7.32	14.71	12.33
	0			9.20	9.17	5.17	9.84	6.25
	+20			3.89	--	--	--	--
96	--	7.61	3.82					
	-10			0.00	6.61	4.23	3.64	--
	0			6.25	8.07	6.33	4.00	--
	+20			2.63	--	--	--	--

^aValues are percent occurrence of cherry red color among all colors within a storage time-freezing rate-final storage temperature combination.

Table 9. Incidence of light grayish red color in ground beef patties with soy throughout storage and according to freezing rate and final storage temperature^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Before freezing	Immediately after freezing, 1 day	Evaluation Time				
				6 mo	9 mo	12 mo	18 mo	24 mo
24	--	22.15	3.33					
	-10			5.50	6.61	2.59	11.86	4.76
	0			2.73	5.13	1.68	5.45	13.19
	+20			1.19	--	--	--	--
48	--	22.58	2.91					
	-10			5.45	5.04	9.47	7.94	5.88
	0			5.36	2.61	2.97	7.27	9.57
	+20			0.65	--	--	--	--
72	--	48.15	5.97					
	-10			7.14	6.25	2.44	8.82	5.48
	0			9.20	2.50	10.34	6.56	5.00
	+20			1.67	--	--	--	--
96	--	30.43	1.91					
	-10			9.46	4.41	6.10	7.27	--
	0			15.00	3.14	4.52	4.00	--
	+20			0.00	--	--	--	--

^aValues are percent occurrence of light grayish red color among all colors within a storage time-freezing rate-final storage temperature combination.

Table 10. General table illustrating sensory scores for surface discoloration in ground beef patties with soy throughout storage according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		6.55 ± .35	6.37 ± .36	6.73 ± .73	6.84 ± .37
Immediately following freezing, 1 day		5.68 ± .80	5.55 ± .61	5.17 ± .86	5.40 ± .62
6 months	-10T	4.37 ± .49	4.37 ± .81	4.06 ± .78	3.54 ± 1.00
	OT	4.05 ± .65	4.17 ± .69	4.73 ± .52	4.26 ± .51
	20T	2.17 ± .50	2.27 ± .51	2.86 ± .63	1.62 ± .47
	20N	2.19 ± .38	1.83 ± .48	2.35 ± .45	1.50 ± .39
9 months	-10T	3.83 ± .82	3.54 ± .53	4.42 ± .72	3.90 ± .64
	-10N	--	--	--	3.48 ± .68
	OT	3.96 ± .67	3.64 ± .65	4.02 ± .58	3.67 ± .72
	ON	--	--	--	3.27 ± .78
12 months	-10T	3.46 ± .46	3.67 ± .41	4.09 ± .52	3.71 ± .62
	-10N	--	--	--	3.65 ± .63
	OT	3.52 ± .54	3.60 ± .50	3.63 ± .65	3.69 ± .72
	ON	--	--	--	3.35 ± .61
18 months	-10N	3.29 ± .33	3.62 ± .32	4.33 ± .66	3.54 ± .84
	ON	2.42 ± .42	2.83 ± .78	3.92 ± .47	2.46 ± .78
24 months	-10N	3.12 ± .65	3.20 ± .52	3.44 ± .58	--
	ON	1.92 ± .65	2.66 ± .47	3.15 ± .51	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Generally, following six months of storage, +20°F produced more discoloration than the other two rates, although this was not the case for patties frozen to 0°F in 72 hours and initially stored at -10°F (Table 11). There were some indications (Table 12) that 0°F rather than -10°F produced more surface discoloration following nine months of storage for certain freezing rates, but the differences were nonsignificant ($P > .05$). After twelve months of storage, more discoloration was noted on patties subjected to the 0°F in 24 hour freezing than 0°F in 72 hour freezing (Table 13). Following eighteen months of storage, the 0°F in 72 hour rate again produced less discoloration, but only if the initial storage was maintained at 0°F (Table 14).

Increases in storage, where significant, always produced more surface discoloration (Table 15). Differences in discoloration immediately evaluated following freezing vs that scored at six months always showed more for +20°F stored product, but in some cases for 0°F stored product as well (Table 16). One of the few differences between six and nine months was the greater discoloration found on the surface of patties frozen to 0°F in 96 hours, initially stored at 0°F and finally stored at -10°F vs the 0°F in 72 hour rate with the same storage temperatures (Table 17). Patties stored initially and finally at 0°F following nine months storage exhibited more discoloration than patties right after freezing. Other initial-final temperature combinations did not deteriorate as much after nine months storage (Table 18).

Following twelve months of storage, all initial-final temperature combinations possessed more discoloration than that observed following freezing with the greatest discoloration being observed for product always

Table 11. Interaction effect of initial storage temperature, final storage temperature and rate of freezing on sensory scores for surface discoloration in ground beef patties with soy following six months storage

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10T	4.37 + .30abc	5.00 + .30a	3.55 + .30abcdefgh	4.34 + .30abc
	0T	4.31 + .30abcd	4.04 + .30abcdefg	4.87 + .30a	4.15 + .30abcdef
	20T	2.33 + .30fghij	2.46 + .30efghij	3.19 + .30abcdefghi	1.54 + .30ij
	20N	2.29 + .30ghij	2.00 + .30hij	2.50 + .30defghij	1.71 + .30ij
0	-10T	4.37 + .30abc	3.75 + .30abcdefgh	4.56 + .30ab	2.75 + .30bcdefghi
	0T	3.79 + .30abcdefgh	4.29 + .30abcde	4.58 + .30ab	4.37 + .30abc
	20T	2.00 + .30hij	2.08 + .30hij	2.54 + .30cdefghij	1.71 + .30ij
	20N	2.08 + .30hij	1.67 + .30ij	2.21 + .30ghij	1.29 + .30j

abcdefghij Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused.

Table 12. Interaction effect of initial storage temperature and freezing rate on sensory scores for surface discoloration in ground beef patties with soy following nine months storage^a

Initial storage temperature, 0°F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	4.29 \pm .19	3.50 \pm .19	4.27 \pm .19	4.06 \pm .19
0	3.50 \pm .19	3.69 \pm .19	4.17 \pm .19	3.50 \pm .19

^aInteraction significant ($P < .05$) by analysis of variance, but not by HSD.

Table 13. Effect of freezing rate on sensory scores for surface discoloration in ground beef patties with soy following twelve months storage

Freezing Rate, hours to 0°F			
24	48	72	96
3.49 \pm .074b	3.64 \pm .074ab	3.86 \pm .086a	3.70 \pm .074ab

ab Means on the same line with the same letters are not different ($P > .05$); Mean \pm S.E.

Table 14. Interaction effect of initial storage temperature and rate of freezing on sensory scores for surface discoloration in ground beef patties with soy following eighteen months storage

Initial storage temperature, 0°F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	2.87 \pm .22bc	3.42 \pm .22abc	3.96 \pm .22ab	3.54 \pm .22abc
0	2.83 \pm .22c	3.04 \pm .22bc	4.29 \pm .22a	2.46 \pm .22c

abc Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.

Table 15 . Effect of various storage time comparisons on sensory scores for surface discoloration in ground beef patties with soy

<u>Evaluation time</u>	
<u>Immediately before freezing</u>	<u>Immediately following freezing, 1 day</u>
6.63 \pm .11a	5.45 \pm .08b
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
5.45 \pm .15a	3.15 \pm .15b
<u>Immediately following freezing, 1 day</u>	<u>9 months^c</u>
5.40 \pm .34a	3.58 \pm .34b
<u>Immediately following freezing, 1 day</u>	<u>9 months^d</u>
5.45 \pm .13a	3.87 \pm .13b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
5.45 \pm .073a	3.66 \pm .073b
<u>Immediately following freezing, 1 day</u>	<u>12 months^c</u>
5.40 \pm .29a	3.60 \pm .29b
<u>9 months</u>	<u>12 months</u>
3.87 \pm .048a	3.66 \pm .048b
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
5.45 \pm .16a	3.30 \pm .16b
<u>Immediately following freezing, 1 day</u>	<u>24 months</u>
5.47 \pm .21a	2.89 \pm .21b
<u>18 months</u>	<u>24 months</u>
3.40 \pm .09a	2.89 \pm .09b

ab Difference between means on the same line significant ($P < .05$);
Mean \pm S.E.

^cIncludes just 0°F in 96 hr product.

^dDoes not include +20°F final storage temperature.

Table 16. Interaction effect of storage time (immediately following freezing, six months) initial and final storage temperature and rate of freezing on sensory scores for surface discoloration in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
6 months	-10		5.68 ± .29a	5.55 ± .29a	5.17 ± .29abc	5.40 ± .29ab
		-10	4.37 ± .29abcde	5.00 ± .29abc	3.55 ± .29cdefgh	4.34 ± .29abcde
		0	4.31 ± .29abcde	4.04 ± .29abcdef	4.87 ± .29abcd	4.15 ± .29abcdef
		20T	2.33 ± .29ghij	2.46 ± .29fghij	3.19 ± .29defghi	1.54 ± .29ij
		20N	2.29 ± .29ghij	2.00 ± .29hij	2.50 ± .29fghij	1.71 ± .29ij
	0	-10	4.37 ± .29abcde	3.75 ± .29bcdefg	4.56 ± .29abcd	2.75 ± .29efghij
		0	3.79 ± .29bcdefg	4.29 ± .29abcde	4.58 ± .29abcd	4.37 ± .29abcde
		20T	2.00 ± .29hij	2.08 ± .29ghij	2.54 ± .29fghij	1.71 ± .29ij
		20N	2.08 ± .29ghij	1.67 ± .29ij	2.21 ± .29ghij	1.29 ± .29j

abcdefghij Any mean comparison with different letters is different (P<.05); Mean ± S.E.; T = Temperature abused;
N = Not temperature abused.

Table 17. Interaction effect of storage time (six, nine months) initial and final storage temperature and rate of freezing on sensory scores for surface discoloration in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
6 months	-10	-10	4.37 ± .28ab	5.00 ± .28a	3.55 ± .28ab	4.34 ± .28ab
		0	4.31 ± .28ab	4.04 ± .28ab	4.87 ± .28a	4.15 ± .28ab
	0	-10	4.37 ± .28ab	3.75 ± .28ab	4.56 ± .28ab	2.75 ± .28b
		0	3.79 ± .28ab	4.29 ± .28ab	4.58 ± .28a	4.37 ± .28ab
9 months	-10	-10	4.46 ± .28ab	3.42 ± .28ab	4.62 ± .28a	4.08 ± .28ab
		0	4.12 ± .28ab	3.58 ± .28ab	3.92 ± .28ab	4.04 ± .28ab
	0	-10	3.21 ± .28ab	3.67 ± .28ab	4.21 ± .28ab	3.71 ± .28ab
		0	3.79 ± .28ab	3.71 ± .28ab	4.12 ± .28ab	3.29 ± .28ab

ab Any mean comparison with the same letters is not different ($P>.05$); Mean ± S.E.

Table 18. Interaction effect of storage time (immediately following freezing, nine months) temperature abuse, initial and final storage temperatures on sensory scores for surface discoloration in ground beef patties with soy

		9 months storage			
Immediately following freezing, 1 day	Temperature abuse	Initial Storage temperature, °F =		-10	
		Final Storage temperature, °F =			
			-10	0	-10
5.40 ± .32a	T	4.08 ± .32ab	4.04 ± .32ab	3.71 ± .32ab	3.29 ± .32b
	N	3.62 ± .32ab	3.79 ± .32ab	3.33 ± .32b	2.75 ± .32b

ab Any mean comparison with the same letters is not different ($P > .05$); Mean ± S.E.; T = Temperature abused; N = Not temperature abused; Includes only 0°F in 96 hr rate.

maintained at 0°F (Table 19). At both nine and twelve months of storage, 0°F initial temperature produced more discoloration than -10°F (Table 20). Following eighteen months of storage, if product had been frozen to 0°F in either 72 or 96 hours and then always stored at -10°F, there was no additional surface discoloration to that noted right after freezing (Table 21). Between twelve and eighteen months, 0°F final storage, but not -10°F, produced an increase in discoloration with the six month advancement in time (Table 22).

General information regarding off-odor is shown in Table 23.

Advancements in storage time, the use of +20°F storage temperature and the 0°F in 96 hour freezing rate all accelerated the onset of off-odor. After six months of storage, 0°F in 96 hour rate showed more off-odor if product had been stored at -10°F final storage temperature (Table 24). This was also true for other final storage temperatures, but then the 0°F in 96 hour rate only possessed more off-odor compared to the 0°F in 72 hour rate. In some isolated comparisons, temperature abuse produced less off-odor (Table 25).

In an interaction of initial and final storage temperature with freezing rate, 0°F in 24 hours produced more off-odor than other rates if the initial storage temperature was -10°F and the final storage temperature was 0°F or the reciprocal of this combination (Table 26). The -10°F initial temperature produced more off-odor between nine and twelve months, while the opposite was true for 0°F initial storage temperature (Table 27). More off-odor was noted on 0°F final stored product in contrast to -10°F stored product after eighteen months of storage (Table 28). After both twelve and eighteen months of storage, the 0°F in 48 and 72 hour rates

Table 20. Effect of initial storage temperature on sensory scores for surface discoloration in ground beef patties with soy following nine and twelve months storage

Evaluation time, months	Initial storage temperature, °F	
	-10	0
9 ^c	3.89 ± .17a	3.27 ± .17b
12 ^d	3.86 ± .06a	3.49 ± .06b

ab Difference between means on the same line significant (P<.05); Mean ± S.E.

^cIncludes just 0°F in 96 hr and both temperature and non-temperature abused product.

^dIncludes just temperature abused product.

Table 22 . Interaction effect of storage time (twelve, eighteen months) and final storage temperature on sensory scores for surface discoloration in ground beef patties with soy

Evaluation time, months	Final storage temperature, °F	
	-10	0
12	3.60 \pm .11a	3.40 \pm .11a
18	3.54 \pm .11a	2.46 \pm .11b

ab Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.; Includes just 0°F in 96 hr and nonabused product.

Table 23. General table illustrating sensory scores for off-odor in ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00
Immediately following freezing, 1 day		4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00
6 months	-10	4.00 ± 0.00	3.96 ± .20	4.00 ± 0.00	3.36 ± .50
	0	3.87 ± .34	3.87 ± .34	4.00 ± 0.00	3.50 ± .51
	20T	2.85 ± .37	2.75 ± .44	3.75 ± .47	2.67 ± .48
	20N	2.96 ± .55	2.83 ± .38	3.00 ± .42	2.40 ± .50
9 months	-10T	3.25 ± .61	3.54 ± .51	3.83 ± .38	3.67 ± .48
	-10N	-----	-----	-----	2.92 ± .41
	0T	3.17 ± .64	3.67 ± .48	3.83 ± .38	3.54 ± .59
	0N	-----	-----	-----	2.83 ± .56
12 months	-10T	3.08 ± .28	3.40 ± .50	3.50 ± .52	3.04 ± .55
	-10N	-----	-----	-----	3.15 ± .59
	0T	3.12 ± .45	3.55 ± .51	3.54 ± .67	3.12 ± .61
	0N	-----	-----	-----	3.05 ± .51
18 months	-10N	2.25 ± .45	2.83 ± .39	3.00 ± .43	2.25 ± .45
	0N	2.00 ± 0.00	2.50 ± .52	2.83 ± .39	1.67 ± .49
24 months	-10N	2.80 ± .41	3.45 ± .51	3.35 ± .51	-----
	0N	2.45 ± .51	2.49 ± .51	3.25 ± .49	-----

^a Mean ± S.D., T = temperature abuse, N = not temperature abused.

Table 24. Interaction effect of final storage temperature and rate of freezing on sensory scores for off-odor in ground beef patties with soy following six months storage

Final storage temperature °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	4.00 \pm .089a	3.96 \pm .089ab	4.00 \pm .089a	3.36 \pm .089cd
0T	3.87 \pm .089ab	3.87 \pm .089ab	4.00 \pm .089a	3.50 \pm .089bc
20T	2.85 \pm .089ef	2.75 \pm .089def	3.75 \pm .089abc	2.67 \pm .089ef
20N	2.96 \pm .089de	2.83 \pm .089ef	3.00 \pm .089de	2.40 \pm .089f

abcdef Any mean comparison with different letters is different ($P < .05$),
Mean \pm S.E., T = temperature abused, N = not temperature abused.

Table 25. Effect of temperature abuse on sensory scores for off-odor in ground beef patties with soy following several storage periods

Evaluation time, months	Temperature abuse	
	T	N
6 ^c	3.00a	2.80b
9 ^d	3.60 \pm .077a	2.87 \pm .077b

ab Difference between means on the same line is significant (P<.05). Mean \pm S.E. T = temperature abuse, N = no temperature abuse.

c Includes just +20°F final storage temperature

d Includes just 0°F in 96 hour rate of freezing

Table 26. Interaction effect of initial storage temperature, final storage temperature and rate of freezing on sensory scores for off-odor in ground beef patties with soy following nine months storage

Initial storage temperature, 0°F	Final storage temperature, 0°F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10	3.58 + .11ab	3.50 + .11abc	3.92 + .11a	3.67 + .11a
	0	3.00 + .11bc	3.67 + .11a	3.92 + .11a	3.67 + .11a
0	-10	2.92 + .11c	3.58 + .11ab	3.75 + .11a	3.67 + .11a
	0	3.33 + .11abc	3.67 + .11a	3.75 + .11a	3.42 + .11abc

abc Any mean comparison with the same letter is not different ($P > .05$), Mean + S.E.

Table 27. Effect of initial storage temperature on sensory scores for off-odor in ground beef patties with soy following several storage periods

Evaluation time, months	Initial storage temperature, °F	
	-10	0
9 ^c	3.40 ± .077a	3.08 ± .077b
12 ^c	2.93 ± .070b	3.25 ± .070a

ab Means on the same line with different letters are different (P<.05)
Mean ± S.E.

^c Includes both temperature and nontemperature abused product.
Includes just 0°F in 96 hour rate.

Table 28. Effect of final storage temperature on sensory scores for off-odor in ground beef patties with soy following eighteen months storage

Final storage temperature, °F	
-10	0
2.58 \pm .077a	2.25 \pm .077b

ab Difference between means significant ($P < .05$). Mean \pm S.E.

produced less off-odor than the 0°F in 24 and 96 hour rates (Table 29). After twenty-four months of storage, 0°F final storage produced more discoloration than -10°F for patties frozen to 0°F in 24 and 48 hours, but not 0°F in 72 hours (Table 30).

Advancements in storage time produced more off-odor on the patties, except between eighteen and twenty-four months of storage where the opposite was true (Table 31). After six months of storage, product stored at +20°F was generally observed to have more off-odor than patties evaluated immediately following freezing (Table 32). Exceptions to this were temperature abused product from the 0°F in 72 hour rate stored initially at either 0 or -10°F. After nine months of storage when +20°F had been eliminated for the 0°F in 24 hour rate, all product finally stored at 0°F and patties stored initially at 0 and finally at -10°F had more off-odor than that found immediately post-freezing (Table 33). Various initial-final temperature combinations did not differ ($P > .05$) between six and nine months of storage if the freezing rates were 0°F in 48, 72 or 96 hours (Table 34). All product stored at 0°F and patties stored initially at -10°F and finally at 0°F possessed more off-odor at six vs nine months when the freezing rate was 0°F in twenty-four hours. Between nine and twelve months (Table 35) only product frozen to 0°F in 96 hours produced more off-odor. However, at twelve months off-odor was as intense on 0°F in 24 hour product as 0°F in 96 hour product. Also, between nine and twelve months, off-odor increased on the temperature abused, but not nonabused patties (Table 36). After twelve months of storage, for product frozen to 0°F in 96 hours, patties stored initially at 0 and finally at -10°F had similar off-odor to that right after freezing (Table 37). In a comparison of

Table 29. Effect of freezing rate on sensory scores for off-odor in ground beef patties with soy following various storage periods

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	3.10 \pm .07b	3.47 \pm .07a	3.52 \pm .07a	3.08 \pm .07b
18	2.12 \pm .011b	2.67 \pm .011a	2.92 \pm .011a	1.96 \pm .011b

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

Table 30 . Interaction effect of final storage temperature and freezing rate on sensory scores for off-odor in ground beef patties with soy following twenty-four months of storage

Final storage temperature, °F	Freezing rate, hours to 0°F		
	24	48	72
-10	2.80 \pm .10b	3.45 \pm .10a	3.35 \pm .14ab
0	2.45 \pm .10c	2.49 \pm .10c	3.25 \pm .14ab

abc Any mean comparison with different letters is different
($P < .05$), Mean \pm S.E.

Table 31. Effects of various storage time comparisons on sensory scores for off-odor in ground beef patties with soy

<u>Evaluation Time</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
4.00 \pm .064a	3.36 \pm .064b
<u>Immediately following freezing, 1 day</u>	<u>9 months^c</u>
4.00 \pm .15a	3.24 \pm .15b
<u>Immediately following freezing, 1 day</u>	<u>9 months^d</u>
4.00 \pm .065a	3.56 \pm .065b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
4.00 \pm .068a	3.30 \pm .068b
<u>Immediately following freezing, 1 day</u>	<u>12 months^e</u>
4.00 \pm .19a	3.09 \pm .19b
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
4.00 \pm .11a	2.41 \pm .11b
<u>12 months^g</u>	<u>18 months^f</u>
3.10 \pm .10a	1.96 \pm .10b
<u>Immediately following freezing, 1 day</u>	<u>24 months</u>
4.00 \pm .09a	2.95 \pm .09b
<u>18 months^h</u>	<u>24 months^g</u>
2.75 \pm .06b	3.00 \pm .06a

ab Differences between means on the same line significant ($P < .05$).
Mean \pm S.E.

^c Includes only 0°F in 96 hour freezing rate.

^d Does not include $\pm 20^\circ\text{F}$ final storage temperature.

^e Includes both temperature and nontemperature abuse, includes only 0°F in 96 hour rate.

^f Includes just nonabused product and 0°F in 96 hour rate.

^g Includes just nonabused product. Does not include 0°F in 96 hour rate.

Table 32. Interaction effect of storage time (immediately following freezing, six months), initial and final storage temperature and freezing rate on sensory scores for off-odor in ground beef with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
6 months	-10	-10	4.00 ± .12a	4.00 ± .12a	4.00 ± .12a	4.00 ± .12a
		-10	4.00 ± .12a	4.00 ± .12a	4.00 ± .12a	3.42 ± .12abcde
		0	4.00 ± .12a	3.92 ± .12a	4.00 ± .12a	3.37 ± .12abcde
		20T	2.80 ± .12efg	2.80 ± .12efg	3.67 ± .12abcd	2.55 ± .12fg
		20N	3.17 ± .12bcdef	2.92 ± .12defg	3.00 ± .12cdefg	2.40 ± .12g
	0	-10	4.00 ± .12a	3.92 ± .12a	4.00 ± .12a	3.30 ± .12abcde
		0	3.75 ± .12ab	3.83 ± .12ab	4.00 ± .12a	3.62 ± .12abcd
		20T	2.90 ± .12defg	2.70 ± .12efg	3.83 ± .12ab	2.79 ± .12efg
		20N	2.75 ± .12efg	2.75 ± .12efg	3.00 ± .12cdefg	2.40 ± .12g

abcdefg Any mean comparisons with different letters are different (P<.05), Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 33. Interaction effect of storage time (immediately following freezing, nine months), initial and final storage temperatures and freezing rate on sensory scores for off-odor in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
9 months	-10	-10	4.00 ± .099a	4.00 ± .099a	4.00 ± .099a	4.00 ± .099a
		0	3.58 ± .099abc	3.50 ± .099abcd	3.92 ± .099ab	3.67 ± .099ab
			3.00 ± .099cd	3.67 ± .099ab	3.92 ± .099ab	3.67 ± .099ab
	0	-10	2.92 ± .099d	3.58 ± .099abc	3.75 ± .099ab	3.67 ± .099ab
		0	3.33 ± .099bcd	3.67 ± .099ab	3.75 ± .099ab	3.42 ± .099abcd

abcd Any mean comparison with the same letters is not different (P>.05), Mean ± S.E.

Table 34 . Interaction effect of storage time, initial and final storage temperatures and freezing rate on sensory scores for off-odor in ground beef patties with soy

Evaluation time, months	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
6	-10	-10	4.00 + .097a	4.00 + .097a	4.00 + .097a	3.42 + .097abcd
		0	4.00 + .097a	3.92 + .097ab	4.00 + .097a	3.37 + .097abcd
	0	-10	4.00 + .097a	3.92 + .097ab	4.00 + .097a	3.30 + .097bcd
		0	3.75 + .097ab	3.83 + .097ab	4.00 + .097a	3.62 + .097abc
9	-10	-10	3.58 + .097abc	3.50 + .097abcd	3.92 + .097ab	3.67 + .097ab
		0	3.00 + .097cd	3.67 + .097ab	3.92 + .097ab	3.67 + .097ab
	0	-10	2.92 + .097d	3.58 + .097abc	3.75 + .097ab	3.67 + .097ab
		0	3.33 + .097bcd	3.67 + .097ab	3.75 + .097ab	3.42 + .097abcd

abcd Any mean comparisons with the same letters are not different ($P>.05$), Mean + S.E.

Table 35. Interaction effect of storage time (nine, twelve months) and freezing rate on sensory scores for off-odor in ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
9	3.21 ± .063cd	3.60 ± .063ab	3.83 ± .063a
12	3.10 ± .063d	3.47 ± .063bc	3.55 ± .077ab
			3.60 ± .063ab
			3.08 ± .063d

abcd Any mean comparison with different letters is different ($P < .05$),
Mean ± S.E.

Table 36. Interaction effect of storage time (nine, twelve months) and temperature abuse on sensory scores for off-odor in ground beef patties with soy

Evaluation time, months	Temperature abuse	
	T	N
9	3.60 \pm .07a	2.87 \pm .07b
12	3.08 \pm .07b	3.10 \pm .07b

ab Any mean comparison with the same letter is not different, Mean \pm S.E.,
 T = temperature abuse, N = not temperature abuse. Includes just 0°F in
 96 hr freezing rate.

Table 37. Effect of storage time (immediately following freezing, twelve months) on sensory scores for off-odor on ground beef patties with soy

		12 Months storage		
		Initial storage temperature, °F =		
		-10	0	0
		Final storage temperature, °F =		
		-10	0	-10
Immediately following freezing, 1 day	Temperature abuse			
4.00 ± .13a	T	2.83 ± .13b	3.08 ± .13b	3.25 ± .13ab
	N	3.00 ± .13b	2.80 ± .13b	3.30 ± .13ab
				3.17 ± .13b
				3.30 ± .13b

ab Any mean comparison with the same letters is not different (P.>05). Mean ± S.E.
T = temperature abused, N = not temperature abused. Includes only 0°F in 96 hour freezing rate.

immediately following freezing with twenty-four months of storage, all initial-final temperature treatments for 0°F in 24 hour frozen product exhibited more off-odor than right after freezing (Table 38). However, for the 0°F in 48 and 72 hour rates, most storage temperature combinations were similar in off-odor to that noted right after freezing.

General data given in Table 39 for sensory (visual) appraisal of freezing burn illustrates that both storage time and the use of +20°F storage encouraged the development of freezer burn. However, the +20°F temperature seemed to bring on more freezer burn between the two variables. Immediately following freezing, more freezer burn was noted on the patties from the slower rates of freezing. This was also true after eighteen months of storage; however, after six months storage, both 0°F in 24 and 96 hour freezing rates showed more freezer burn (Table 40). Following six months of storage, -10°F final temperature produced less freezer burn (Table 41). After nine months of storage, there were some indications of more freezer burn to be associated with the 0°F in 24 hour rate, but considerable variation existed in the values according to final storage temperature (Table 42). The use of 0°F rather than -10°F final storage temperature produced more freezer burn at both eighteen and twenty-four months of storage (Table 43). However, for just patties frozen to 0°F in 96 hours, there was a tendency following twenty-four months of storage for more freezer burn to appear on patties constantly held at -10°F (Table 44).

Advancements in storage time produced more freezer burn (Table 45). After six months, for the 0°F in 24, 48 and 96 hour rates, various initial and final temperature combinations did not generate more freezer burn to that detected right after freezing (Table 46). However, for the 0°F in 96

Table 38. Interaction effect of storage time (immediately after freezing, twenty-four months), initial and final storage temperature and freezing rate on sensory scores for off-odor in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day					
24 months	-10	-10	4.00 ± .14a	4.00 ± .14a	4.00 ± .14a
			2.90 ± .14bcd	3.50 ± .14ab	3.46 ± .22ab
	0	0	2.50 ± .14cd	2.50 ± .14cd	3.30 ± .14abcd
			2.70 ± .14bcd	3.40 ± .14abc	3.30 ± .14abcd
			2.40 ± .14d	2.49 ± .14cd	3.27 ± .22abcd

abcd Any mean comparisons with the same letters are not different ($P > .05$), Mean ± S.E.

Table 39. General table illustrating sensory scores for freezer burn in ground beef patties with soy throughout storage according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		--	--	--	--
Immediately following freezing, 1 day					
6 months	-10T	2.58 ± .54	2.51 ± .62	2.62 ± .73	3.72 ± .90
	0T	1.80 ± .29	2.79 ± .69	2.80 ± .49	2.43 ± .59
	20T	2.23 ± .44	2.87 ± .52	3.29 ± .65	2.42 ± .57
	20N	1.21 ± .25	1.65 ± .43	1.63 ± .45	1.25 ± .30
		1.65 ± .40	1.73 ± .57	1.83 ± .48	1.37 ± .40
9 months	-10T	1.75 ± .49	2.08 ± .70	2.33 ± .49	2.04 ± .41
	-10N	--	--	--	1.81 ± .44
	0T	1.77 ± .36	2.21 ± .62	2.63 ± .70	1.96 ± .46
	0N	--	--	--	2.17 ± .56
12 months	-10T	2.06 ± .47	2.14 ± .43	2.16 ± .54	1.85 ± .48
	-10N	--	--	--	2.12 ± .45
	0T	2.10 ± .49	2.32 ± .41	2.09 ± .47	2.28 ± .49
	0N	--	--	--	2.03 ± .57
18 months	-10N	1.33 ± .39	1.92 ± .60	2.44 ± .48	2.17 ± .61
	0N	1.46 ± .33	1.58 ± .60	2.07 ± .34	2.00 ± .64
24 months	-10N	1.45 ± .36	1.75 ± .57	1.70 ± .52	--
	0N	1.83 ± .52	1.49 ± .36	2.10 ± .45	--

a) mean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 40. Effect of freezing rate at various storage times on sensory scores for freezer burn in ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing, 1 day	2.58 \pm .16b	2.51 \pm .16b	2.62 \pm .16ab	3.72 \pm .16a
6 months	1.72 \pm .088b	2.26 \pm .088a	2.39 \pm .088a	1.87 \pm .088b
18 months	1.40 \pm .16b	1.75 \pm .16ab	2.26 \pm .16a	2.08 \pm .16ab

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 41. Effect of final storage temperature on sensory scores for freezer burn in ground beef patties with soy following six months storage

<u>Final storage temperature, °F</u>			
<u>-10T</u>	<u>0T</u>	<u>20T</u>	<u>20N</u>
2.45 <u>+</u> .088b	2.70 <u>+</u> .088a	1.43 <u>+</u> .088b	1.65 <u>+</u> .088b

ab Means on the same line with different letters are different ($P < .05$); Mean + S.E.; T = Temperature abused; N = Not temperature abused.

Table 42. Interaction effect of initial storage temperature, final storage temperature and rate of freezing on sensory scores for freezer burn in ground beef patties with soy following nine months storage^a

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
		24	48	72	96
-10	-10	1.62 + .28	2.46 + .28	2.29 + .28	1.83 + .28
	0	1.67 + .28	1.87 + .28	3.14 + .28	2.00 + .28
0	-10	1.87 + .28	1.71 + .28	2.46 + .28	2.25 + .28
	0	1.87 + .28	2.54 + .28	2.12 + .28	1.92 + .28

^aInteraction significant ($P < .05$) by analysis of variance, but not by HSD; Mean \pm S.E.

Table 43. Effect of final storage temperature on sensory scores for freezer burn in ground beef patties with soy following eighteen and twenty-four months storage

Evaluation time, months	Final storage temperature, °F	
	-10	0
18	3.70 \pm .11a	2.91 \pm .11b
24	3.25 \pm .17a	2.58 \pm .17b

ab Difference between means on the same line significant ($P < .05$); Mean \pm S.E.

Table 44. Interaction effect of initial storage temperature and final storage temperature on sensory scores for freezer burn in ground beef patties with soy following twenty-four months of storage

Initial storage temperature, °F	Final storage temperature, 0°F	
	-10	0
-10	1.38 \pm .14	1.88 \pm .12
0	1.91 \pm .12	1.71 \pm .14

^aInteraction significant ($P < .05$) by analysis of variance, but not by HSD. Mean \pm S.E. Does not include 0°F in 96 hr rate. Includes only nonabused product.

Table 45. Effects of various storage time comparisons on sensory scores for freezer burn in ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	6 months
2.86 \pm .13a	2.06 \pm .13b
Immediately following freezing, 1 day	9 months ^c
3.72 \pm .25a	1.99 \pm .25b
Immediately following freezing, 1 day	9 months ^d
2.86 \pm .14a	2.10 \pm .14b
6 months	9 months
2.58 \pm .059a	2.10 \pm .059b
Immediately following freezing, 1 day	12 months
2.86 \pm .11a	2.13 \pm .11b
Immediately following freezing, 1 day	12 months ^c
3.72 \pm .24a	2.07 \pm .24b
Immediately following freezing, 1 day	18 months
2.86 \pm .17a	1.87 \pm .17b
Immediately following freezing, 1 day	24 months ^e
2.57 \pm .12a	1.74 \pm .12b

ab Differences between means on the same line are significant ($P < .05$); Mean \pm S.E.

^cIncludes only 0°F in 96 hr freezing rate.

^dDoes not include +20°F final storage temperature.

^eDoes not include 0°F in 96 hr freezing rate.

Table 46. Interaction effect of storage time (immediately following freezing, six months) initial and final storage temperature and rate of freezing on sensory scores for freezer burn in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
0 months	-10	-10T	2.58 ± .24abcdefg	2.51 ± .24abcdefg	2.62 ± .24abcdefg	3.72 ± .24a
		0T	1.81 ± .24cdefg	2.92 ± .24abcde	2.79 ± .24abcde	2.27 ± .24bcdefg
		20T	2.33 ± .24abcdefg	2.58 ± .24abcdefg	3.37 ± .24ab	2.34 ± .24abcde
		20N	1.25 ± .24fg	1.75 ± .24defg	1.69 ± .24efg	1.23 ± .24fg
6 months	0	-10T	1.58 ± .24efg	2.17 ± .24bcdefg	1.83 ± .24cdefg	1.58 ± .24efg
		0T	1.79 ± .24cdefg	2.67 ± .24abcdef	2.81 ± .24abcde	2.59 ± .24abcde
		20T	2.12 ± .24bcdefg	3.17 ± .24abcd	3.21 ± .24abc	2.50 ± .24abcde
		20N	1.17 ± .24g	1.54 ± .24efg	1.58 ± .24efg	1.27 ± .24fg
			1.29 ± .24efg	1.83 ± .24cdefg	1.17 ± .24g	

abcdefg Any mean comparison with different letters is different (P<.05); mean ± S.E.; T = Temperature abused; N = Not temperature abused.

hour rate, +20°F final storage temperature produced more freezer burn to that scored right after freezing. The same situation occurred after nine months of storage whereas all temperature combinations for the 0°F in 96 hour rate had more freezer burn compared to that noted just after freezing (Table 47). This was somewhat dependent on the use of the temperature abuse treatment. Patties initially and finally stored at 0°F and receiving temperature abuse had similar freezer burn to that recorded after freezing (Table 48). Again, after twelve months of storage, this storage time difference of 0°F in 96 vs the other rates was detected (Table 49).

Aerobic plate counts obtained from the ground beef patties with soy are given next. Values generally were not greatly affected by the study, although there was a slight reduction with storage time (Table 50). Since there were some significant ($P < .05$) differences in bacterial counts in the formulations before freezing, data adjustments were necessary prior to statistical analyses to account for these differences. Following standardization of counts, 0°F in 72 hours produced the highest counts after freezing, six, nine, twelve and eighteen months (Table 51). At twelve and eighteen months of storage, both 0°F in 24 and 96 hour rates had lower counts than 0°F in 48 and 72 hour freezing rates. Freezing in itself produced a slight reduction in aerobic plate counts (Table 52).

After six months of storage, +20°F final storage had lower counts than -10°F and 0°F storage temperatures (Table 53). After twelve months, patties subjected to the temperature abuse supported lower bacterial numbers than patties not abused (Table 54). In Table 55, -10°F final storage produced lower numbers than 0°F at both eighteen and twenty-four months of storage.

Table 47. Interaction effect of storage time (immediately following freezing, nine months) initial and final storage temperatures and rate of freezing on sensory scores for freezer burn in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
Immediately following freezing, 1 day			2.58 + .25abc	2.51 + .25abc	2.62 + .25abc	3.72 + .25a
9 months	-10	-10	1.62 + .25c	2.46 + .25abc	2.29 + .25abc	1.83 + .25bc
	0	0	1.67 + .25c	1.87 + .25bc	3.14 + .25ab	2.00 + .25bc
	0	-10	1.87 + .25bc	1.71 + .25bc	2.46 + .25abc	2.25 + .25bc
		0	1.87 + .25bc	2.54 + .25abc	2.12 + .25bc	1.92 + .25bc

abc Any mean comparison with the same letters is not different ($P > .05$); Mean + S.E.

Table 48. Effect of storage time (immediately following freezing, twelve months) on sensory scores for freezer burn on ground beef patties with soy

		12 Months storage		
		Initial storage temperature, °F =		
		-10	0	0
Immediately following freezing, 1 day	Temperature abuse	Final storage temperature, °F =		
		-10	0	-10 0
3.72 ± .23a	T	1.75 ± .23b	2.14 ± .23b	1.96 ± .23b 2.42 ± .23ab
	N	2.05 ± .23b	2.25 ± .23b	2.20 ± .23b 1.82 ± .23b

ab Any mean comparison with the same letters is not different (P.>05). Mean + S.E.
T = temperature abused, N = not temperature abused. Includes only 0°F in 96 hour freezing rate.

Table 49. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperatures and rate of freezing on sensory scores for freezer burn in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10	-10	2.58 + .20ab	2.51 + .20ab	2.62 + .20ab	3.72 + .20a
			2.16 + .20b	2.18 + .20b	1.94 + .20b	1.75 + .20b
			2.08 + .20b	2.25 + .20b	2.00 + .30b	2.14 + .20b
	0	0	1.96 + .20b	2.10 + .20b	2.37 + .20b	1.96 + .20b
			2.12 + .20b	2.40 + .20b	2.12 + .20b	2.42 + .20b

abc Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.

Table 50. General table illustrating aerobic plate counts for ground beef patties with soy throughout storage times and according to final storage temperature and rate of freezing - no statistical analyses

Evaluation Time	Final Storage Time	Freezing Rate, hours to 0°F			
		24	48	72	96
Before freezing		6.81 + .22	6.30 + .05	6.23 + .06	6.64 + .08
Immediately after freezing, 1 day		6.65 + .16	6.17 + .05	6.23 + .07	6.40 + .05
6 months	-10T	6.28 + .06	5.88 + .04	6.08 + .07	6.12 + .11
	0T	6.32 + .14	5.93 + .08	6.11 + .08	6.09 + .03
	+20T	6.07 + .08	5.68 + .06	5.90 + .08	5.93 + .11
	+20N	6.20 + .08	5.75 + .20	5.99 + .25	5.78 + .11
9 months	-10T	6.43 + .05	5.93 + .08	6.00 + .10	6.23 + .19
	-10N				6.12 + .14
	0T	6.42 + .06	5.85 + .08	5.94 + .07	6.14 + .11
	0N				6.16 + .11
12 months	-10T	6.10 + .15	5.90 + .18	6.04 + .05	5.88 + .04
	-10N				6.04 + .05
	0T	6.14 + .09	5.85 + .08	6.07 + .03	5.95 + .07
	0N				6.05 + .04
18 months	-10N	6.35 + .08	5.96 + .03	5.95 + .02	5.89 + .10
	0N	6.24 + .06	5.83 + .08	5.89 + .08	5.66 + .09
24 months	-10N	6.40 + .13	5.76 + .19	5.99 + .04	
	0N	6.25 + .22	5.55 + .09	5.92 + .09	

aMean + S.D. T = temperature abused, N = not temperature abused. Values are \log_{10}/g .

Table 51. Effect of freezing rate on aerobic plate counts for ground beef patties with soy following various storage periods -- data adjusted for differences prior to freezing

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing, 1 day	6.33 \pm .023b	6.30 \pm .023ab	6.50 \pm .023a	6.20 \pm .023b
6 months	5.90 \pm .047b	6.00 \pm .047ab	6.29 \pm .047a	5.84 \pm .047b
9 months	6.10 \pm .039ab	6.08 \pm .039ab	6.24 \pm .039a	6.05 \pm .039b
12 months	5.80 \pm .043c	6.06 \pm .043b	6.32 \pm .049a	5.78 \pm .043c
18 months	5.97 \pm .022c	6.08 \pm .022b	6.19 \pm .022a	5.64 \pm .022d

abc Means on the same line with different letters are different (P<.05). Mean \pm S.E.

Table 52. Effect of freezing on aerobic plate counts for ground beef patties with soy

<u>Evaluation Time</u>	
<u>Before freezing</u>	<u>Immediately after freezing, 1 day</u>
6.50 \pm .019a	6.36 \pm .029b

ab Differences between means are significant ($P < .05$). Means \pm S.E.
Values are \log_{10}/g .

Table 53. Effect of final storage temperature on aerobic plate counts for ground beef patties with soy following six months storage

<u>Final Storage Temperature</u>			
<u>-10T</u>	<u>0T</u>	<u>+20T</u>	<u>+20N</u>
6.09 \pm 0.024a	6.11 \pm 0.024a	5.90 \pm 0.024b	5.93 \pm 0.024b

ab Means on the same line with different letters are different ($P < .05$).
 Means \pm S.E. Values are \log_{10}/g . T = temperature abused, N = not
 temperature abused.

Table 54. Effect of temperature abuse on aerobic plate counts for ground beef patties with soy following 12 months storage

<u>Temperature Abuse</u>	
<u>T</u>	<u>N</u>
5.92 \pm .017b	6.04 \pm .017a

ab Differences between means are significant ($P < .05$). Means \pm S.E.
 Values are \log_{10}/g . Includes only 0°F in 96 hour frozen product.
 T = temperature abused, N = not temperature abused.

Table 55. Effect of final storage temperature on aerobic plate counts for ground beef patties with soy following 18 and 24 months of storage

Storage Time, months	Final Storage Temperature, °F	
	-10	0
18	6.04 + .016a	5.90 + .016b
24	6.05 ± .034a	5.90 ± .034b

ab Means on the same line with different letters are different ($P < .05$).
Means ± S.E. Values are \log_{10}/g . Includes only nonabused product.

Compared to sampling immediately post-freezing, storage time advancements always produced a decrease in aerobic plate counts (Table 56). At six months storage, 0°F in 72 hours generated higher counts than the other freezing rates, while at nine months of storage, this freezing level still maintained the higher counts, but they were not different than those noted for 0°F in 24 hours freezing (Table 57). At nine months of storage, patties initially stored at 0°F and -10°F final storage temperatures had counts similar to those found right after freezing (Table 58). Counts between nine and twelve months of storage decreased for both patties frozen to 0°F in 24 and 96 hours (Table 59). In addition, at twelve months, the counts for these two rates were lower than the other two rates. Following eighteen months, patties finally stored at 0°F had lower counts than patties stored at -10°F and the 0°F patties stored for twelve months (Table 60).

After eighteen months of storage, many of the various initial and final storage temperature combinations for the 0°F in 48 hour freezing rate were similar to the counts detected immediately following freezing (Table 61). The 0°F in 24 hour rate had higher counts in all initial-final temperature combinations. Adjusting these data for differences prior to freezing resulted in few changes in interpretation of the differences in bacterial counts (Table 62). Between eighteen and twenty-four months of storage, patties originally frozen to 0°F in 48 hours underwent a reduction in counts while no differences were found between these two times for patties frozen to 0°F in 24 or 72 hours (Table 63). The 0°F in 48 hour rate product generally produced lower counts at these times than the 0°F in 24 and 72 hours. However, adjusting the data for pre-freezing bacterial differences removed these freezing rate effects (Table 64).

Table 56. Effects of storage time (comparisons of immediately following freezing with various storage times, months) on aerobic plate counts for ground beef patties with soy

<u>Evaluation time comparisons</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
6.36 \pm .017a	6.01 \pm .017b
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
6.36 \pm .020a	6.12 \pm .020b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
6.36 \pm .024a	5.99 \pm .024b
<u>9 months</u>	<u>12 months^c</u>
6.16 \pm .029a	5.98 \pm .029b
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
6.36 \pm .014a	5.97 \pm .014b
<u>Immediately following freezing, 1 day</u>	<u>24 months</u>
6.36 \pm .024a	5.97 \pm .024b

ab Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E. Values are \log_{10}/g .

^cIncludes just 0°F in 96 hour freezing rate.

Table 57. Interaction effect of storage time (six, nine months) and freezing rate on aerobic plate counts for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	5.98 \pm .030c	6.09 \pm .030bc	6.36 \pm .030a	5.97 \pm .030c
9	6.10 \pm .030bc	6.08 \pm .030c	6.24 \pm .030ab	6.05 \pm .030c

abc Any mean comparison with different letters is different
($P < .05$). Mean \pm S.E.

Table 58. Effect of storage time (immediately following freezing, 9 months) on aerobic plate counts for ground beef patties with soy

		9 Months Storage	
Immediately after freezing, 1 day	Initial storage temperature, °F =	-10	0
	Final storage temperature, °F =	-10	0
6.36 ± 0.034a	6.21 ± 0.034b	6.10 ± 0.034b	6.08 ± 0.034b
			6.08 ± 0.034b

ab Means on the same line with the same letter are not different ($P > .05$). Mean ± S.E.
Values are log 10/g.

Table 59 . Interaction effect of storage time (nine, twelve months) and rate of freezing on aerobic plate counts for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, month	Freezing rate, hours to 0°F			
	24	48	72	96
9	6.10 \pm .043b	6.08 \pm .043b	6.24 \pm .043ab	6.05 \pm .043b
12	5.80 \pm .043c	6.06 \pm .043b	6.32 \pm .053a	5.78 \pm .043c

abc Any mean comparison with different letters is different
($P < .05$). Mean \pm S.E.

Table 60. Interaction effect of storage time (twelve, eighteen months) and final storage temperature on aerobic plate counts for ground beef patties with soy

Evaluation Time, months	Final Storage Temperature, °F	
	-10	0
12	6.04 + .032a	6.05 + .032a
18	5.89 + .032a	5.66 + .032b

ab Any mean comparisons with the same letter are not different ($P > .05$).
Means + S.E. Values are \log_{10}/g . Includes on nonabused, 0°F in 96 hour frozen product.

Table 61. Interaction effect of freezing rate and storage time (immediately following freezing, 18 months) on aerobic plate counts for ground beef patties with soy

		18 Months Storage			
Freezing Rate, hrs to 0°F	Immediately after freezing, 1 day	Initial storage temperature, °F =		Final storage temperature, °F =	
		-10	0	-10	0
24	6.65 + 0.044a	6.37 + 0.044b	6.29 + 0.044b	6.33 + 0.044b	6.18 + 0.044b
48	6.17 + 0.044bc	5.96 + 0.044cd	5.82 + 0.044de	5.95 + 0.044cd	5.84 + 0.044de
72	6.23 + 0.044b	5.96 + 0.044cd	5.94 + 0.044cd	5.94 + 0.044cd	5.84 + 0.044de
96	6.40 + 0.044a	5.84 + 0.044de	5.72 + 0.044de	5.95 + 0.044cd	5.60 + 0.044e

abcde Any mean comparisons with different letters are different ($P < .05$). Mean \pm S.E.
Values are log /g. Includes only nonabused product.

Table 62. Interaction effect of storage time (Immediately following freezing, eighteen months), initial final storage temperature and rate of freezing on aerobic plate counts for ground beef patties with soy — data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following, freezing, 1 day			6.33 ± .044ab	6.36 ± .044ab	6.50 ± .044a	6.26 ± .044abc
18 months	-10	-10	6.05 ± .044cdef	6.15 ± .044bcd	6.23 ± .044bcd	5.70 ± .044ghi
		0	5.97 ± .044def	6.01 ± .044cdef	6.21 ± .044bcd	5.58 ± .044hi
	0	-10	6.01 ± .044cdef	6.14 ± .044bcd	6.21 ± .044bcd	5.81 ± .044fgh
		0	5.87 ± .044efg	6.03 ± .044cdef	6.11 ± .044bcde	5.46 ± .044i

abcdefghi Any mean comparison with different letters is different (P<.05). Mean ± S.E.

Table 63. Interaction effect of storage time (eighteen, twenty-four months) and rate of freezing on aerobic plate counts for ground beef patties with soy

Evaluation Time, months	Freezing Rate, hours to 0°F		
	24	48	72
18	6.29 \pm 0.044a	5.89 \pm 0.044b	5.92 \pm 0.044b
24	6.32 \pm 0.044a	5.65 \pm 0.044c	5.95 \pm 0.062b

ab Any mean comparison with a different letter is different ($P < .05$).
Mean \pm S.E. Values are \log_{10}/g . Includes only nonabused product.

Table 64. Interaction effect of storage time (eighteen, twenty-four months), and freezing rate on aerobic plate counts for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	5.97 \pm .044bc	6.08 \pm .044ab	6.19 \pm .044ab
24	6.00 \pm .044abc	5.84 \pm .044c	6.22 \pm .044a

abc Any mean comparison with different letters is different (P<.05). Mean \pm S.E.

Information pertaining to TBA values for patties with soy are given next. The general table (Table 65) shows escalation in values due to: (1) the use of +20°F final storage, (2) freezing to 0°F in 96 hours, and (3) longer storage times (Table 65). There were some minor changes in TBA values between formulations and freezing rates just before and after freezing; but the differences weren't the same (Table 66). Following eighteen months of storage, 0°F in 96 hour rate produced higher TBA values than the other three rates and after twenty-four months of storage, 0°F in 72 hours produced higher values than 0°F in 24 and 48 hour rates. The before-after freezing values for the various freezing rates were actually involved in an interaction where freezing produced decreases in TBA values for the 0°F in 48 and 72 hour rates (Table 67). An interaction of freezing rate and final storage time at six months showed that non-temperature abused patties frozen to 0°F in 96 hours and stored at +20°F had higher TBA values than all other rate-temperature combinations (Table 68). After nine months of storage, the only rate to show a decrease in TBA values between -10°F and 0°F was the 0°F in 96 hours. This 0°F in 96 hour rate also had a higher value than all other rates when product had been finally stored at -10°F (Table 69). Overall, at nine months, TBA values were lower on 0°F finally stored product compared to -10°F, while the opposite was true for product stored eighteen months (Table 70).

In some specific cases (0°F in 96 hour frozen product, temperature abused product) at nine months of storage, -10°F initial storage generated lower counts (Table 71). Overall, at nine months, temperature abuse resulted in lower TBA values than nonabuse (Table 72).

Table 65. General table illustrating TBA values for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing--no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		1.53 + .094	1.71 + .11	1.82 + .14	1.40 + .07
Immediately following freezing, 1 day		1.77 + .12	1.41 + .14	1.53 + .14	1.43 + .15
6 months	-10T	2.04 + .12	1.97 + .18	1.94 + .37	2.59 + .74
	0T	2.13 + .12	1.98 + .11	1.62 + .16	1.91 + .13
	20T	2.21 + .29	2.58 + .44	1.72 + .32	2.72 + .39
	20N	2.36 + .32	2.66 + .54	1.97 + .43	3.90 + 1.00
9 months	-10T	1.37 + .19	1.43 + .16	1.49 + .13	1.77 + .23
	-10N	-----	-----	-----	2.05 + .29
	0T	1.49 + .13	1.30 + .08	1.47 + .12	1.51 + .16
	0N	-----	-----	-----	1.97 + .30
12 months	-10T	1.72 + .29	1.58 + .21	1.57 + .084	2.09 + .24
	-10N	-----	-----	-----	2.06 + .24
	0T	1.67 + .26	1.76 + .29	1.79 + .21	2.25 + .35
	0N	-----	-----	-----	1.92 + .24
18 months	-10N	2.21 + .38	2.20 + .34	2.04 + .28	3.06 + .38
	0N	2.44 + .43	2.74 + .47	2.07 + .34	3.55 + .57
24 months	-10N	2.81 + .43	2.64 + .31	2.23 + .35	-----
	0N	3.14 + .64	2.64 + .38	2.06 + .30	-----

^a Mean + S.D. T=temperature abused. N=not temperature abused.

Table 66. Effect of freezing rate at various storage times on TBA values in ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing	1.53 \pm .056ab	1.71 \pm .056ab	1.82 \pm .056a	1.4 \pm .056b
Immediately following freezing, 1 day	1.77 \pm .038a	1.41 \pm .038b	1.53 \pm .038ab	1.43 \pm .038b
18 months	2.32 \pm .093bc	2.47 \pm .093b	2.05 \pm .093c	3.31 \pm .093a
24 months	2.97 \pm .099a	2.64 \pm .099a	2.14 \pm .14b	

abc Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E.

Table 67. Interaction effect of storage time (before and after freezing) and rate of freezing on TBA values for ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	1.53 \pm .06bc	1.71 \pm .06ab	1.82 \pm .06a	1.40 \pm .06c
Immediately following freezing, 1 day	1.77 \pm .06ab	1.41 \pm .042c	1.53 \pm .042bc	1.43 \pm .042c

abc Any mean comparisons with different letters are different ($P < .05$).

Mean \pm S.E.

Table 68. Interaction effect of final storage temperature and rate of freezing on TBA values for ground beef patties with soy following six months storage

Final storage temperature	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	2.04 \pm .16bcd	1.97 \pm .16bcd	1.94 \pm .16bcd	2.59 \pm .16b
0T	2.13 \pm .16bcd	1.98 \pm .16bcd	1.62 \pm .16d	1.91 \pm .16bcd
20T	2.21 \pm .16bcd	2.58 \pm .16bc	1.72 \pm .16cd	2.72 \pm .16b
20N	2.36 \pm .16bcd	2.66 \pm .16b	1.97 \pm .16bcd	3.9 \pm .16a

abcd Any mean comparisons with different letters are different ($P < .05$).

Mean \pm S.E. T=temperature abused. N=not temperature abused.

Table 69. Interaction effect of final storage temperature and rate of freezing on TBA values in ground beef patties with soy following nine months of storage

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	1.37 \pm .042b	1.43 \pm .042b	1.49 \pm .042b	1.77 \pm .042a
0	1.49 \pm .042b	1.30 \pm .042b	1.47 \pm .042b	1.51 \pm .042b

ab Any mean comparison with the same letter is not different ($P > .05$).
Mean \pm S.E.

Table 70. Effect of final storage temperature on TBA values in ground beef patties with soy at various storage times

Evaluation time, months	Final storage temperature, °F	
	-10	0
9 ^c	1.91 + .05a	1.74 + .05b
18	2.38 + .066b	2.70 + .066a

ab Differences between means on the same line are significant ($P < .05$)
Mean \pm S.E.

c Includes only 0°F in 96 hr product.

Table 71. Effects of initial storage temperature on TBA values in ground beef patties with soy following nine months of storage

	Initial storage temperature, °F	
	-10	0
Only 0°F in 96 hr product	1.69 ± .05b	1.97 ± .05a
Includes only temperature abused product	1.43 ± .02b	1.53 ± .02a

ab Means on the same line with different letters are different ($P < .05$).
Mean ± S.E.

Table 72. Effect of temperature abuse on TBA values for ground beef patties with soy following nine months storage

<u>Temperature abuse</u>	
<u>T</u>	<u>N</u>
1.64 \pm .05b	2.01 \pm .05a

ab Differences between means significant ($P < .05$). Mean \pm S.E.

Includes only 0° in 96 hr product.

Except for the function of freezing itself, and six vs nine months, storage generated higher TBA values (Table 73). At six months of storage, +20°F final storage produced substantially higher TBA values than that found right after freezing, but only for 0°F in 48 and 96 hour freezing rates (Table 74). Following nine months of storage, some of the initial-final temperature combinations under the 0°F in 24 hour rate (-10°F final regardless of initial storage temperature) had lower TBA values than that found right after freezing (Table 75). Following freezing, only patties held at -10 and 0°F final temperature from the 0°F initial temperature had higher TBA values than those noted right after freezing (Table 76); but this was only for nonabused rather than temperature abused patties. Between nine and twelve months, TBA values increased for patties initially held at -10°F. This did not happen for patties stored at 0°F (Table 77).

After twelve months of storage and for the 0°F in 96 hour freezing rate, patties finally stored at 0°F, regardless of initial temperature, had higher TBA values than that found immediately post-freezing (Table 78). This difference was not detected for the other freezing rates. Also, at twelve months, many of the initial-final temperature abuse combinations had higher TBA values than that found right after freezing, especially with temperature abused product (Table 79). Following eighteen months of storage, all of the initial-final temperature combinations for 0°F in 96 hour rate and all but -10°F initial and final for the 0°F in 48 hour rate had higher TBA values than that noted just post-freezing (Table 80). Between eighteen and twenty-four months of storage, only patties frozen to 0°F in 24 hours increased in TBA values. However, for both storage times, 0°F in 72 hours had lower values than 0°F in 24 hours (Table 81).

Table 73. Effect of various storage time comparisons on TBA values in ground beef patties with soy

Evaluation Time	
Immediately before freezing 1.62 ± .03a	Immediately following freezing, 1 day 1.54 ± .02b
Immediately following freezing, 1 day 1.54 ± .11b	6 months 2.27 ± .11a
Immediately following freezing, 1 day ^c 1.43 ± .09b	9 months ^c 1.83 ± .09a
Immediately following freezing, 1 day ^c 1.43 ± .12b	12 months ^c 2.08 ± .12a
Immediately following freezing, 1 day 1.54 ± .062b	12 months 1.80 ± .062a
Immediately following freezing, 1 day 1.54 ± .093b	18 months 2.54 ± .093a
Immediately following freezing, 1 day 1.54 ± .11b	24 months 2.60 ± .11a
6 months ^d 2.02 ± .04a	9 months ^d 1.48 ± .04b
9 months ^d 1.48 ± .031b	12 months ^d 1.80 ± .031a
12 months ^c 1.99 ± .097b	18 months ^c 3.31 ± .097a

ab Means on the same line with different letters are different (P<.05).

Mean ± S.E.

c Includes only 0°F in 96 hr freezing rate product.

d Includes only temperature abused product.

Table 74. Interaction effect of storage time immediately following freezing, initial storage temperature, final storage temperature and rate of freezing on TBA values for ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			1.77 ± .21cdef	1.41 ± .21f	1.53 ± .21ef	1.43 ± .21f
6 months	-10	-10T	2.02 ± .21bcdef	2.03 ± .21bcdef	1.81 ± .21cdef	2.45 ± .21bcdef
		0T	2.10 ± .21bcdef	1.94 ± .21bcdef	1.65 ± .21def	1.94 ± .21bcdef
		20T	2.19 ± .21bcdef	2.57 ± .21bcde	1.83 ± .21cdef	2.52 ± .21bcde
		20N	2.44 ± .21bcdef	2.74 ± .21bc	1.71 ± .21cdef	3.84 ± .21a
	0	-10T	2.06 ± .21bcdef	1.90 ± .21bcdef	2.07 ± .21bcdef	2.72 ± .21bc
		0T	2.16 ± .21bcdef	2.02 ± .21bcdef	1.58 ± .21def	1.88 ± .21cdef
		20T	2.24 ± .21bcdef	2.58 ± .21bcd	1.61 ± .21def	2.93 ± .21ab
		20N	2.28 ± .21bcdef	2.58 ± .21bcd	2.22 ± .21bcdef	3.97 ± .21a

abcdef Any mean comparisons with the same letters are not different ($P > .05$). Mean ± S.E. T=temperature abused, N=not temperature abused.

Table 75. Interaction effect of storage time (immediately following freezing, nine months), initial storage temperature, final storage temperature and rate of freezing on TBA values for ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day		1.77 + .06ab	1.41 + .06bcd	1.53 + .06bc	1.43 + .06bcd
9 months	-10	1.39 + .06cd	1.38 + .06cd	1.46 + .06bcd	1.66 + .06abc
	0	1.45 + .06bcd	1.27 + .06d	1.43 + .06bcd	1.41 + .06bcd
	-10	1.35 + .06cd	1.48 + .06bcd	1.51 + .06bcd	1.89 + .06a
	0	1.52 + .06bcd	1.33 + .06cd	1.51 + .06bcd	1.62 + .06abcc

abcd Any mean comparison with the same letters is not different ($P > .05$). Mean + S.E.

Table 76. Effect of storage time (immediately following freezing, nine months)
on TBA values for ground beef patties with soy

Immediately after freezing, 1 day	Temperature abuse	9 months evaluation time			
		Initial storage temperature, °F =			
		Final storage temperature, °F =			
1.43 + .09c	T	-10	-10	0	0
	N	1.66 + .09bc	1.41 + .09c	1.89 + .09abc	1.62 + .09bc
		1.87 + .09abc	1.80 + .09abc	2.23 + .09a	2.14 + .09ab

abc Any mean comparisons with the same letters are not different ($P > .05$). Mean + S.E. 0°F in 96-hr product only.

Table 77. Interaction effect of storage time (nine, twelve months) and initial storage temperature on TBA values in ground beef patties with soy

Evaluation time, months	Initial storage temperature, °F	
	-10	0
9	1.69 \pm .05b	1.97 \pm .05a
12	2.07 \pm .05a	2.09 \pm .05a

ab Any mean comparisons with the same letters are not different ($P > .05$).
Mean \pm S.E. Includes only 0°F in 96 hr and both temperature and non-temperature abused product.

Table 78. Interaction effect of storage time (immediately following freezing, twelve months), initial storage temperature, final storage temperature and rate of freezing on TBA values of beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			1.77 + .11abc	1.41 + .11c	1.53 + .11bc	1.43 + .11c
12 months	-10	-10	1.69 + .11abc	1.56 + .11bc	1.58 + .11bc	2.20 + .11ab
		0	1.70 + .11abc	1.52 + .11bc	1.89 + .17abc	2.12 + .11ab
	0	-10	1.76 + .11abc	1.59 + .11bc	1.55 + .11bc	1.99 + .11abc
		0	1.63 + .11bc	1.99 + .11abc	1.67 + .11bc	2.37 + .11a

abc Any mean comparisons with the same letters are not different (P>.05). Mean ± S.E.

Table 79. Effect of storage time (immediately following freezing, twelve months) on TBA values for ground beef patties with soy

Immediately following freezing, 1 day	Temperature abuse	12 Months storage		
		Initial storage temperature, °F =		0
		-10	0	
1.43 ± .11b	T	Final storage temperature, °F =		0
		-10	-10	
		2.20 ± .11a	2.12 ± .11a	1.99 ± .11ab
	N	2.10 ± .11a	1.84 ± .11ab	2.02 ± .11ab
				2.00 ± .11ab

ab Any mean comparison with the same letters is not different (P.>05). Mean ± S.E.
T = temperature abused, N = not temperature abused. Includes only 0°F in 96 hour freezing rate.

Table 80. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature, final storage temperature and rate of freezing on TBA values in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			1.77 ± .16fghi	1.41 ± .16i	1.53 ± .16ghi	1.43 ± .16hi
18 months	-10	-10	2.26 ± .16cdefghi	2.14 ± .16cdefghi	2.14 ± .16cdefghi	3.03 ± .16ab
		0	2.39 ± .16cdefgh	2.78 ± .16abcde	2.04 ± .16efghi	3.61 ± .16a
	0	-10	2.15 ± .16cdefghi	2.56 ± .16bcdef	1.95 ± .16efghi	3.1 ± .16ab
		0	2.48 ± .16cdefg	2.70 ± .16abcdef	2.09 ± .16defghi	3.49 ± .16ab

abcdefghi Any mean comparison with different letters is different (P<.05). Mean ± S.E.

Table 81. Interaction effect of storage time (eighteen, twenty-four months) and rate of freezing on TBA values for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	2.32 \pm .078bcd	2.47 \pm .078bc	2.05 \pm .078d
24	2.97 \pm .078a	2.64 \pm .078ab	2.2 \pm .078cd

abcd Any mean comparisons with different letters are different (P<.05). Mean \pm S.E.

Sensory scores of a general format for broiled ground beef flavor intensity is shown in Table 82. Scores in general at any time were not particularly high. Advancements in storage, especially beyond nine months, decreased the intensity. Immediately following freezing, patties from the 0°F in 96 hour rate had less flavor intensity than the 0°F in 24 and 72 hour rate (Table 83). This was not detected just prior to freezing. After six months of storage, the use of +20°F final storage temperature produced a decline for flavor intensity vs the other two rates, but only for the 0°F in 72 hour rate and then only for the nontemperature abused +20°F stored product (Table 84). Temperature abuse created more intense ground beef flavor following six months of storage (Table 85).

The 0°F in 24 and 48 hour freezing rates produced higher flavor scores than the other two freezing rates following nine months of storage. After twenty-four months of storage 0°F in 24 and 72 hour rates were given high flavor intensity scores for patties compared to the 0°F in 48 hour rate (Table 86). Again at twelve months of storage the application of a temperature abuse back at 45 and 60 days of storage produced more intense beef flavor than no abuse (Table 87).

At eighteen months of storage, patties frozen to 0°F in 96 hours were rated as having less beef patty flavor than the other three rates if they had initially been stored at -10°F. No differences due to freezing rate were found coupled with the 0°F initial storage temperature (Table 88). Following twenty-four months of storage, for patties finally stored at -10°F, those initially stored at 0°F possessed less ground beef flavor intensity than those initially held at -10°F (Table 89).

Table 82. General table illustrating the sensory scores for ground beef flavor intensity in ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		3.61 ± .75	3.72 ± 1.03	3.80 ± .88	3.75 ± .83
Immediately following freezing, 1 day		3.75 ± .92	3.74 ± .83	3.80 ± .86	3.17 ± .94
6 months	-10T	3.32 ± .77	3.47 ± .94	3.78 ± .79	3.05 ± .79
	0T	3.53 ± .89	3.42 ± .90	3.71 ± 1.02	3.00 ± .74
	20T	3.53 ± .66	3.59 ± .89	3.22 ± .76	3.21 ± .66
	20N	3.34 ± .89	3.08 ± .87	2.81 ± .62	3.42 ± .78
9 months	-10T	3.83 ± .52	3.92 ± .72	3.44 ± .87	3.44 ± .83
	-10N	--	--	--	3.67 ± .65
	0T	3.90 ± .71	3.81 ± .74	3.23 ± .84	3.53 ± .76
	0N	--	--	--	3.55 ± .70
12 months	-10T	3.16 ± .80	3.09 ± .54	2.87 ± .67	3.11 ± .76
	-10N	--	--	--	2.80 ± .75
	0T	2.86 ± .73	3.23 ± .67	3.03 ± .69	3.15 ± .80
	0N	--	--	--	2.82 ± .66
18 months	-10N	3.01 ± .94	2.99 ± .76	3.15 ± .74	2.54 ± .76
	0N	3.03 ± .76	3.01 ± .71	2.97 ± .62	2.60 ± .66
24 months	-10N	3.12 ± .63	2.50 ± .53	3.19 ± .61	--
	0N	2.95 ± .51	2.37 ± .40	2.99 ± .60	--

^aMean ± S.D.; T = temperature abused; N = Not temperature abused.

Table 83. Interaction effect of storage time (just before and after freezing) and rate of freezing on sensory scores for ground beef flavor intensity in ground beef with soy

Evaluation time	Freezing Rate, hours to 0°F			
	24	48	72	96
Before freezing	3.61 \pm .13ab	3.72 \pm .13ab	3.80 \pm .13a	3.75 \pm .13a
Immediately following freezing, 1 day	3.75 \pm .13a	3.74 \pm .09ab	3.80 \pm .09a	3.17 \pm .09b

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E.

Table 84. Interaction effect of final storage temperature and rate of freezing on sensory scores for ground beef flavor intensity in ground beef patties with soy following six months storage

Final storage temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10T	3.33 \pm .15 ab	3.47 \pm .15 ab	3.78 \pm .15 a	3.05 \pm .15 ab
0T	3.53 \pm .15 ab	3.42 \pm .15 ab	3.71 \pm .15 a	3.00 \pm .15 ab
20T	3.53 \pm .15 ab	3.59 \pm .15 ab	3.22 \pm .15 ab	3.21 \pm .15 ab
20N	3.34 \pm .15 ab	3.09 \pm .15 ab	2.81 \pm .15 b	3.42 \pm .15 ab

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 85. Effect of temperature abuse on sensory scores for ground beef flavor intensity in ground beef patties with soy following six months storage

Temperature Abuse	
T	N
3.39a	3.16b

ab Difference between means significant ($P < .05$). Mean. T = temperature abused, N = not temperature abused. Includes just +20°F final storage temperature. S.E. not calculable.

Table 86. Effect of freezing rate on sensory scores for ground beef flavor intensity in ground beef patties with soy following either nine or twenty-four months of storage

Evaluation time, months	Freezing Rate, hours to 0°F			
	24	48	72	96
9	3.80 \pm .083a	3.87 \pm .083a	3.34 \pm .083b	3.48 \pm .083b
24	3.04 \pm .058a	2.44 \pm .058b	3.09 \pm .082a	--

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

Table 87. Effect of temperature abuse on sensory scores for ground beef flavor intensity in ground beef patties with soy following twelve months storage

<u>Temperature Abuse</u>	
<u>T</u>	<u>N</u>
3.13 \pm .069a	2.81 \pm .069b

ab Difference between means significant ($P < .05$). Mean \pm S.E. T = temperature abused, N = not temperature abused. Includes just 0°F in 96 hr freezing rate.

Table 88. Interaction effect of initial storage temperature and rate of freezing on sensory scores for ground beef flavor intensity in ground beef patties with soy following eighteen months storage

Initial storage temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10	2.94 \pm .10a	3.17 \pm .10a	3.06 \pm .10a	2.35 \pm .10b
0	3.10 \pm .10a	2.83 \pm .10ab	3.07 \pm .10a	2.79 \pm .10ab

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E.

Table 89. Interaction effect of initial storage temperature and final storage temperature on sensory scores for ground beef flavor intensity in ground beef patties with soy following twenty-four months of storage

Initial storage temperature, °F	Final storage temperature, °F	
	-10	0
-10	3.04 \pm .082a	2.83 \pm .067ab
0	2.68 \pm .067b	2.86 \pm .082ab

ab Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.

Increases in storage (where differences were significant, $P < .05$) indicated a reduction in ground beef flavor intensity (Table 90). Patties subjected to 0°F in 96 hour freezing had less beef flavor following six months vs the other rates, but was no different from the other rates at nine months of storage. Also, there were no differences between six and nine months for patties frozen to 0°F in 96 hours (Table 91). Between nine and twelve months, flavor intensity values decreased for 0°F in 24 and 48 hour frozen patties, but not for the other two rates (Table 92). Both temperature and nontemperature abused product decreased in flavor intensity between nine and twelve months, but the decrease was more pronounced for nonabused patties (Table 93). Patties from the 0°F in 24 hour rate that had been stored at 0°F final storage temperature regardless of initial storage temperature for twelve months had lower flavor values than those evaluated right after freezing (Table 94). Many of the initial-final temperature combinations for the 0°F in 72 hour rate also had lower beef patty flavor values than the immediate post-freezing evaluations. Between eighteen and twenty-four months of storage, flavor values declined for the 0°F in 48 hour freezing rate, but not for the 0°F in 24 and 72 hour rates (Table 95).

The following tables depict changes in frequency of occurrence for specific flavors as a result of various variables in the study. Immediately post-freezing sour was more prevalent in the 0°F in 48 hour rate patties along with loss "unidentified" flavors compared to the other rates (Table 96). There was also a tendency even at that time of evaluation of more rancid flavor to be associated with slower rates of

Table 90. Effect of various storage time comparisons on sensory scores for ground beef flavor intensity in ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	6 months
3.62 \pm .11a	3.34 \pm .11b
Immediately following freezing, 1 day	12 months
3.62 \pm .066a	3.07 \pm .066b
Immediately following freezing, 1 day	18 months
3.62 \pm .089a	2.91 \pm .089b
12 months ^c	18 months ^c
2.81 \pm .040a	2.57 \pm .040b
Immediately following freezing, 1 day ^d	24 months ^d
3.76 \pm .08a	2.83 \pm .08b

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

^cIncludes only 0°F in 96 hr freezing rate.

^dDoes not include 0°F in 96 hr freezing rate.

Table 91. Interaction effect of storage time (six, nine months) and rate of freezing on sensory scores for ground beef flavor intensity in ground beef patties with soy

Evaluation time, months	Freezing Rate, hours to 0°F			
	24	48	72	96
6	3.43 \pm .12ab	3.44 \pm .12ab	3.75 \pm .12a	3.02 \pm .11b
9	3.86 \pm .12a	3.87 \pm .12a	3.34 \pm .12ab	3.48 \pm .11ab

ab Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.



Table 92. Interaction effect of storage time (nine, twelve months) and rate of freezing on sensory scores for ground beef flavor intensity in ground beef patties with soy

Evaluation time, months	Freezing Rate, hours to 0°F			
	24	48	72	96
9	3.86 \pm .088a	3.87 \pm .088a	3.34 \pm .088bc	3.48 \pm .088ab
12	3.01 \pm .088c	3.16 \pm .088bc	3.01 \pm .11c	3.13 \pm .088bc

abc Any mean comparison with the same letters is not different ($P > .05$).

Table 93. Interaction effect of temperature abuse and storage time (nine, twelve months) on sensory scores for ground beef flavor intensity in ground beef patties with soy

Temperature Abuse	Evaluation Time, months	
	9	12
T	3.48 \pm .073a	3.13 \pm .073b
N	3.61 \pm .073a	2.81 \pm .073b

ab Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 94. Interaction effect of storage time (immediately following freezing, twelve months), initial storage temperature, final storage temperature, and freezing rate on sensory scores for ground beef flavor intensity in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			3.75 ± .12ab	3.74 ± .12ab	3.80 ± .12a	3.17 ± .12abc
12 months	-10	-10 0	3.12 ± .12abc	3.12 ± .12abc	2.81 ± .12c	3.14 ± .12abc
			2.97 ± .12c	3.34 ± .12abc	2.97 ± .12c	3.29 ± .12abc
	0	-10 0	3.19 ± .12abc	3.06 ± .12bc	2.94 ± .12c	3.08 ± .12bc
			2.75 ± .12c	3.12 ± .12abc	3.12 ± .12abc	3.01 ± .12c

abc Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E.

Table 95. Interaction effect of storage time (eighteen, twenty-four months) and freezing rate on sensory scores for ground beef flavor intensity in ground beef patties with soy

Evaluation time, months	Freezing Rate, hours to 0°F		
	24	48	72
18	3.02 \pm .096a	3.00 \pm .096a	3.06 \pm .096a
24	3.04 \pm .096a	2.44 \pm .096b	3.02 \pm .14a

ab Any mean comparison with the same letters is not different ($P > .05$). Mean \pm S.E.

Table 96. Detectable flavor scores assigned to ground beef patties with soy according to freezing rate immediately following freezing^a

Detectable Flavors	Freezing Rate, hrs to 0°F			
	24	48	72	96
Sour	2.63	14.52	3.39	1.82
Bitter	2.63	3.23	6.78	0.00
Metallic	13.16	12.90	5.08	1.27
Sweet	5.26	9.68	10.17	0.00
Rancid	10.53	14.52	16.95	23.64
Unidentified	65.79	45.16	57.63	67.27

Chi-square = 28.65, $P < .018$.

^aValues are percentages of scores assigned within a freezing rate category.

freezing. With the exception of the 0°F in 24 hour rate, patties stored at +20°F had more indication of rancid flavor than the other rates (Table 97) following six months of storage. Except for the 0°F in 96 hour rate, sweet was more prevelant in the -10°F final stored product compared to the other two rates. After nine months of storage, most of the detectable non-ground beef flavors were categorized in the unidentified category. However, approximately 1/3 of the flavors for the patties from the 0°F in 96 hour rate were classified as rancid regardless of final storage temperature (Table 98). Table 99 shows that in contrast to temperature abused product, nontemperature abused product had substantially more of the evaluations classified as rancid following twelve months storage. After eighteen months of storage, 0°F finally stored patties were rated as being more rancid than patties stored at -10°F with the exception of the 0°F in 96 hour freezing rate (Table 100).

An evaluation of just the changes in frequency of rancid flavor across time for the various freezing rate-final storage temperature combinations is depicted in Table 101. Freezing in itself produced some increase in rancidity with the biggest increase occurring during the first six months. At twelve months, there was a decrease in the occurrence of rancid flavor (although less of a drop for 0°F in 96 hour product) compared to nine months followed by an increase at eighteen and twenty-four months.

General values for juiciness are presented in Table 102. There was a slight tendency for juiciness to become less with progressions in storage time. Freezing in itself did not change juiciness except for product frozen to 0°F in 96 hours, where juiciness was reduced (Table 103). Since there were some significant ($P < .05$) differences in juiciness prior to

Table 97. Detectable flavor scores assigned to ground beef patties with soy according to freezing rate - final storage temperature combinations following six months storage^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Detectable Flavors						
		Sour	Bitter	Metallic	Sweet	Rancid	Salty	Unidentified
24	-10	1.75	5.26	5.26	10.53	49.12	0.00	28.07
	0	10.42	4.17	10.42	8.33	41.67	0.00	25.00
	+20	4.17	7.29	18.75	5.21	38.54	0.00	26.04
48	-10	2.44	4.88	7.32	17.07	34.15	0.00	34.15
	0	2.38	7.14	9.52	4.76	47.62	0.00	28.57
	+20	4.90	6.86	15.69	2.94	50.00	0.00	19.61
72	-10	0.00	0.00	16.67	10.00	40.00	3.33	30.00
	0	7.69	3.85	11.54	15.36	30.77	0.00	30.77
	+20	4.06	2.04	7.14	3.06	54.08	0.00	29.59
96	-10	9.30	6.98	11.63	0.00	51.16	0.00	20.93
	0	4.76	9.52	9.52	2.38	45.24	0.00	28.57
	+20	2.38	7.14	11.90	3.57	52.36	0.00	22.62

Chi-square = 86.01, $P < .045$.
 a values are percentages of scores assigned within a freezing rate - final storage temperature combination.

Table 98. Detectable flavor scores assigned to ground beef patties with soy according to freezing rate - final storage temperature combinations following twelve months storage^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Detectable Flavors						
		Sour	Bitter	Metallic	Sweet	Rancid	Salty	Unidentified
24	-10	0.00	9.80	7.64	1.96	13.73	0.00	66.67
	0	1.85	7.41	12.11	0.00	16.67	0.00	62.96
48	-10	0.00	3.92	3.92	1.96	13.73	0.00	76.47
	0	2.08	6.25	4.17	0.00	4.17	0.00	83.33
72	-10	1.89	7.55	11.32	0.00	15.09	0.00	64.15
	0	0.00	10.26	10.26	7.69	15.38	2.50	53.85
96	-10	5.71	5.71	3.81	0.95	33.33	0.00	50.48
	0	4.08	5.10	6.12	1.02	32.65	0.00	51.02

Chi-square = 77.98, $P < 0.0001$.

^aValues are percentages of scores assigned within a freezing rate - final storage temperature combinations.

Table 99. Detectable flavor scores assigned to ground beef patties with soy according to temperature abuse following twelve months storage^a

Detectable Flavors	Temperature Abuse	
	T	N
Sour	1.99	5.15
Bitter	6.72	6.19
Metallic	6.47	8.25
Sweet	1.49	1.03
Rancid	16.67	40.21
Salty	0.25	0.00
Unidentified	66.42	39.18

Chi-square = 33.63, $P < .0001$.

^aValues are percentages of scores assigned within a temperature abuse category. T = temperature abused, N = not temperature abused.

Table 100. Detectable flavor scores assigned to ground beef patties with soy according to freezing rate - final storage temperature combinations following eighteen months storage^a

Freezing Rate, °F to 0°	Final Storage Temperature, °F	Detectable Flavors					
		Sour	Bitter	Metallic	Sweet	Rancid	Unidentified
24	-10	1.85	5.56	1.85	3.70	25.93	61.11
	0	3.51	5.26	0.00	0.00	40.35	50.88
48	-10	0.00	7.55	5.66	9.43	26.42	50.94
	0	5.45	12.73	1.82	7.27	34.55	38.18
72	-10	3.51	0.00	5.26	3.51	17.54	70.18
	0	1.54	3.08	1.54	0.00	29.23	64.62
96	-10	7.32	4.88	2.44	0.00	41.46	43.90
	0	12.50	15.00	5.00	2.50	32.50	32.50

Chi-square = 64.74, $P < .002$.

Values are percentages of scores assigned within a freezing rate - final storage temperature combination.

Table 101. Incidence of rancid flavor in ground beef patties with soy throughout storage and according to freezing rate and final storage temperature^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Before freezing	Immediately after freezing, 1 day	Evaluation Time				
				6 mo	9 mo	12 mo	18 mo	24 mo
24	--	3.33	10.53	49.12	42.31	13.73	25.93	38.64
	-10			41.67	60.00	16.67	40.35	54.17
	+20			38.54	--	--	--	--
48	--	0.00	14.52	34.15	38.78	13.73	26.42	40.00
	-10			47.62	39.53	4.17	34.55	44.00
	+20			50.00	--	--	--	--
72	--	9.68	16.95	40.00	41.51	15.09	17.54	43.33
	-10			30.77	41.51	15.38	29.23	45.71
	+20			54.08	--	--	--	--
96	--	7.69	23.64	51.16	47.31	33.33	41.46	--
	-10			45.24	48.43	32.65	32.50	--
	+20			52.38	--	--	--	--

^aValues are percent occurrence of rancid flavor among all flavors within a storage time-freezing rate-final storage temperature combination.

Table 102. General table illustrating the sensory scores for juiciness in ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.54 ± .59	4.25 ± 1.17	4.62 ± .88	4.94 ± .94
Immediately following freezing, 1 day		4.62 ± .73	4.22 ± .66	4.46 ± .72	4.11 ± 1.07
6 months	-10T	4.33 ± .64	4.17 ± .87	4.31 ± .69	4.22 ± .69
	0T	4.23 ± .71	4.19 ± .68	3.97 ± .76	3.86 ± .82
	20T	4.50 ± .77	4.26 ± .69	4.16 ± .69	3.98 ± .60
	20N	4.41 ± .76	4.11 ± .79	3.89 ± .84	4.33 ± .67
9 months	-10T	4.17 ± .69	4.66 ± .64	4.17 ± .58	4.44 ± .75
	-10N	--	--	--	4.70 ± .47
	0T	4.25 ± .63	4.66 ± .53	4.22 ± .75	4.45 ± .71
	0N	--	--	--	4.75 ± .53
12 months	-10T	3.98 ± .77	4.00 ± .63	3.84 ± .95	3.93 ± .89
	-10N	--	--	--	4.36 ± .64
	0T	3.97 ± .97	4.08 ± .60	3.65 ± .71	4.10 ± .91
	0N	--	--	--	4.32 ± .58
18 months	-10N	3.97 ± .62	3.89 ± .63	3.82 ± .57	4.23 ± .87
	0N	3.83 ± .57	3.96 ± .72	3.67 ± .65	4.02 ± .68
24 months	-10N	3.52 ± .46	3.71 ± .61	3.77 ± .57	--
	0N	4.05 ± .64	3.50 ± .54	3.73 ± .69	--

^aMean ± S.D.; T = temperature abused; N = Not temperature abused.

Table 103. Interaction effect of storage time (just before and after freezing) and rate of freezing on sensory scores for juiciness in ground beef patties with soy

Evaluation time	Freezing Rate, hours to 0°F			
	24	48	72	96
Before freezing	4.54 \pm .15 ab	4.25 \pm .15 b	4.62 \pm .15 ab	4.94 \pm .15 a
Immediately following freezing, 1 day	4.62 \pm .15 ab	4.22 \pm .10 b	4.46 \pm .10 ab	4.11 \pm .10 b

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E.

freezing, (patties frozen to 0°F in 96 hours higher than patties frozen to 0°F in 48 hours) data were adjusted for these differences (Table 104).

Following these adjustments, patties from the 0°F in 96 hour rate were noted to be less juicy than patties frozen to 0°F in either 24 or 48 hours immediately post-freezing and following six months. After twelve months, patties frozen to 0°F in 96 hours were found to be less juicy than those frozen to 0°F in 48 hours.

Increasing storage time usually produced a decrease in sensory scores for juiciness, however, following nine months, values were higher than those noted right after freezing (Table 105). Between six and nine months, juiciness scores became higher for patties frozen to 0°F in 48 hours, but not for the other rates (Table 106). Adjusting these data for pre-freezing differences in juiciness did not alter this difference between six and nine months (Table 107).

Mouthcoating scores were not greatly affected by study variables, but were slightly lower (indicative of more mouthcoating with fat) for product frozen to 0°F in 96 hours (Table 108). After six months of storage, patties stored at +20°F were rated as having more mouthcoating than patties stored at -10 and 0°F (Table 109). Perhaps this is due to more moisture loss during storage for +20°F stored patties, thus making the fat content higher and more detectable as mouthcoating. Also, at six months, temperature abused product had more mouthcoating than nonabused product (Table 110). Mouthcoating became slightly more pronounced with storage, except between nine and twelve months of storage (Table 111). Patties following six months that were stored at +20°F or were stored both initially and finally at -10°F had more mouthcoating than was found

Table 104. Effect of freezing rate on sensory scores for juiciness in ground beef patties with soy following various periods of storage - data adjusted for differences prior to freezing

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing, 1 day	4.68 \pm .11a	4.56 \pm .11a	4.42 \pm .11ab	3.76 \pm .11b
6 months	4.42 \pm .095a	4.52 \pm .095a	4.05 \pm .095ab	3.75 \pm .095b
12 months	4.03 \pm .15ab	4.38 \pm .15a	3.71 \pm .17b	3.66 \pm .15b

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

Table 105. Effect of various storage time comparisons on sensory scores for juiciness in ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	9 months
4.11 \pm .20b	4.59 \pm .20a
Immediately following freezing, 1 day	12 months
4.35 \pm .14a	3.93 \pm .14b
9 months ^C	12 months ^C
4.58 \pm .09a	4.18 \pm .09b
9 months	12 months
4.38 \pm .07a	3.93 \pm .07b
Immediately following freezing, 1 day	18 months
4.35 \pm .09a	3.92 \pm .09b
Immediately following freezing, 1 day	24 months
4.44 \pm .12a	3.74 \pm .12b

ab Differences between means on the same line are significant ($P < .05$).
Mean \pm S.E.

^CIncludes just 0°F in 96 hr freezing rate.

Table 106. Interaction effect of storage time (six, nine months) and rate of freezing on sensory scores for juiciness in ground beef patties with soy

Evaluation time, months	Freezing Rate, hours to 0°F			
	24	48	72	96
6	4.28 \pm .096 ab	4.18 \pm .096 b	4.14 \pm .096 b	4.04 \pm .096 b
9	4.21 \pm .096 ab	4.66 \pm .096 a	4.19 \pm .096 b	4.44 \pm .096 ab

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E.

Table 107. Interaction effect of storage time (six, nine months) and freezing rate on sensory scores for juiciness in ground beef patties with soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	4.33 \pm .096b	4.52 \pm .096b	4.10 \pm .096bc	3.69 \pm .096c
9	4.26 \pm .096b	4.99 \pm .096a	4.16 \pm .096bc	4.09 \pm .096bc

abc Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E.

Table 108. General table illustrating sensory scores for mouth coating in ground beef patties with soy throughout storage and according to final storage temperature and freezing rate - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing Rate, hours to 0°F			
		24	48	72	96
Before freezing		6.37 ± .59	6.32 ± .53	6.30 ± .89	6.23 ± .95
Immediately following freezing, 1 day		6.40 ± .51	6.49 ± .69	6.25 ± .71	6.20 ± .66
6 months	-10T	5.97 ± 1.05	6.06 ± .94	6.10 ± .75	6.00 ± .96
	0T	6.17 ± .68	6.09 ± 1.04	6.16 ± .73	5.91 ± 1.04
	20T	5.85 ± .84	5.70 ± .90	5.80 ± .95	5.90 ± 1.03
	20N	6.06 ± .72	6.09 ± .69	6.02 ± .72	5.67 ± .72
9 months	-10T	5.98 ± .97	6.22 ± .94	5.91 ± .92	5.97 ± .84
	-10N	--	--	--	5.75 ± 1.11
	0T	5.90 ± 1.04	6.16 ± 1.00	5.85 ± 1.16	6.08 ± .72
	0N	--	--	--	5.72 ± 1.23
12 months	-10T	6.19 ± 1.17	6.25 ± 1.22	6.30 ± 1.36	6.27 ± 1.08
	-10N	--	--	--	6.12 ± 1.13
	0T	6.06 ± 1.18	6.26 ± 1.26	6.38 ± 1.39	6.16 ± .82
	0N	--	--	--	6.11 ± 1.00
15 months	-10N	6.50 ± .46	6.29 ± .47	6.25 ± .40	6.02 ± .52
	0N	6.39 ± .46	6.21 ± .55	6.18 ± .45	5.98 ± .43
24 months	-10N	6.36 ± .51	6.59 ± .43	6.37 ± .48	--
	0N	6.27 ± .52	6.45 ± .44	6.38 ± .47	--

Mean ± S.E. T = temperature abused; N = not temperature abused.

Table 109. Effect of final storage temperature on sensory scores for mouth coating in ground beef patties with soy following six months storage

Final Storage Temperature, °F			
-10T	0T	20T	20N
6.03 ± .047a	6.03 ± .047a	5.81 ± .047b	5.96 ± .047ab

ab Means on the same line with the same letters are not different ($P > .05$); Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 110. Effect of temperature abuse on sensory scores for mouthcoating in ground beef patties with soy following six months storage

Temperature Abuse	
T	N
5.81b	5.96a

ab Difference between means significant ($P < .05$). Mean. Includes just +20°F final storage temperature.
T = temperature abused, N = not temperature abused. S.E. not calculable.

Table 111. Effects of various storage time comparisons on sensory scores for mouth coating in ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	6 months
6.33 \pm .067a	5.97 \pm .067b
Immediately following freezing, 1 day	9 months
6.33 \pm .07a	6.01 \pm .07b
Immediately following freezing, 1 day	18 months
6.33 \pm .045a	6.22 \pm .045b
9 months ^c	12 months ^c
6.01 \pm .036b	6.24 \pm .038a
9 months ^d	12 months ^d
5.88 \pm .080b	6.17 \pm .080a

ab Differences between means on the same line significant ($P < .05$).
Mean \pm S.E.

^cIncludes just temperature abused product.

^dIncludes just 0°F in 96 hr freezing rate product.

immediately after freezing (Table 112). At nine months of storage, all initial-final temperature combinations had more mouthcoating than just after freezing except for patties initially and finally stored at -10°F (Table 113). However, only patties stored initially at -10°F and finally at 0°F had more mouthcoating than that observed just post-freezing (Table 114). After eighteen months of storage, slower freezing rates produced more mouthcoating (Table 115). Evaluations at twenty-four months showed 0°F in 48 hours to produce less mouthcoating in patty samples than 0°F in 24 and 72 hours. An interaction of freezing rate and these two storage times revealed that less mouthcoating was detected at twenty-four months of storage, but only for the 0°F in 48 hour rate (Table 116). Most of the initial-final temperature combinations at twenty-four months showed more mouthcoating for 0°F in 24 hour frozen product and less mouthcoating for 0°F in 96 hour product compared to immediately following freezing (Table 117).

The following series of tables presents some of the more interesting findings for patties with soy and which consists of tenderness evaluations. Immediately following freezing, it appeared that faster rates of freezing produced greater initial tenderness in beef patties as evaluated by sensory approaches (Table 118). A rather substantial difference in tenderness occurred pre-freezing for initial tenderness and thus required data adjustments. Once these adjustments were made, patties from the 0°F in 24 hour freezing rate were found to be initially more tender (5 chews) than 0°F in 96 hour product immediately post-freezing and after nine and twelve months of freezer storage (Table 119). Likewise, 0°F in 72 hour patties were rated as being initially more tender than 0°F in 72 hour patties after six, nine and twenty-four months of storage. With the exception of

Table 112. Effect of storage time (immediately following freezing, six months) on sensory scores for mouth coating in ground beef patties with soy

		6 months storage					
Immediately following freezing, 1 day	Temperature Abuse	Initial Storage Temperature, °F =					
		Final Storage Temperature, °F =					
6.33 ± .063a	T	-10	-10	-10	-10	0	0
	N	6.02 ± .063bc	6.06 ± .063abc	5.78 ± .063c	6.05 ± .063abc	6.11 ± .063ab	5.85 ± .063bc
		--	--	5.90 ± .063bc	--	--	6.02 ± .063bc

abc Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E. T = temperature abused; N = not temperature abused.

Table 113. Effect of storage time (immediately following freezing, nine months) on sensory scores for mouth coating in ground beef patties with soy

Immediately following freezing, 1 day	9 months storage		
	Initial Storage		
	Temperature, °F =		
	Final Storage		
		-10	0
		-10	-10
6.33 ± .067 ^a	6.09 ± .067 ^{ab}	6.04 ± .067 ^b	5.94 ± .067 ^b
			5.97 ± .067 ^b

ab Means on the same line with the same letter are not different ($P > .05$); Mean ± S.E.

Table 114. Effect of storage time (immediately following freezing, eighteen months) on sensory scores for mouth coating in ground beef patties with soya^a

Immediately following freezing, 1 day	18 months storage			
	Initial Storage			
	Temperature, °F =			
	Final Storage			
		-10		0
	Temperature, °F =	-10	0	-10
6.33 ± .040a	6.26 ± .040ab	6.13 ± .040b	6.27 ± .040ab	6.24 ± .040ab
				0

ab Means on the same line with the same letters are not different ($P > .05$). Mean ± S.E.
Includes only nonabused product.

Table 115. Effect of freezing rate on sensory scores for mouth coating in ground beef patties with soy following eighteen and twenty-four months of storage

Evaluation Time, months	Freezing rate, hours to 0°F			
	24	48	72	96
18	6.44 \pm .046a	6.25 \pm .046ab	6.21 \pm .046b	6.00 \pm .046c
24	6.31 \pm .026b	6.52 \pm .026a	6.37 \pm .037b	--

abc Means on the same line with different letters are different ($P < .05$).
 Mean \pm S.E.

Table 116. Interaction effect of storage time (eighteen, twenty-four months) and freezing rate on sensory scores for mouth coating in ground beef patties with soy

Evaluation Time, months	Freezing Rate, hours to 0°F		
	24	48	72
18	6.44 \pm .040ab	6.25 \pm .040bc	6.21 \pm .040c
24	6.31 \pm .040bc	6.52 \pm .040a	6.36 \pm .056abc

abc Any mean comparison with the same letters is not different.
Mean \pm S.E.

Table 117. Interaction effect of storage time (immediately following freezing, twenty-four months), initial storage temperature, final storage temperature and freezing rate on sensory scores for mouth coating in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day					
			6.40 ± .048c	6.49 ± .048b	6.25 ± .048e
24 months	-10	-10	6.36 ± .048d	6.50 ± .048b	6.49 ± .073b
	0	0	6.25 ± .048e	6.46 ± .048b	6.36 ± .046d
	-10	-10	6.36 ± .048d	6.68 ± .048a	6.25 ± .048e
	0	0	6.29 ± .048e	6.43 ± .048c	6.42 ± .073c

abcde Any mean comparison with different letters is different (P<.05). mean ± S.E.

Table 118. General table illustrating the sensory scores for initial tenderness in ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		5.75 + .66	5.87 + .90	6.05 + .59	6.37 + .58
Immediately following freezing, 1 day		5.56 + .84	5.08 + .75	5.11 + .73	4.57 + .84
6 months	-10T	5.39 + .78	5.03 + .73	4.95 + .81	5.43 + .60
	0T	5.20 + .61	5.14 + .67	5.04 + .72	5.38 + .59
	20T	4.98 + .63	5.22 + .65	4.96 + .60	5.20 + .51
	20N	4.98 + .68	4.86 + .61	4.47 + .72	5.10 + .67
9 months	-10T	5.19 + .70	4.92 + .57	5.06 + .75	5.19 + .56
	-10N	--	--	--	4.95 + .56
	0T	5.12 + .58	5.12 + .63	5.06 + .43	5.25 + .58
	0N	--	--	--	5.55 + .60
12 months	-10T	5.39 + .68	5.48 + .59	5.73 + .54	5.48 + .72
	-10N	--	--	--	5.23 + .63
	0T	5.36 + .74	5.42 + .58	5.71 + .70	5.50 + .63
	0N	--	--	--	5.25 + .67
18 months	-10N	5.15 + .69	5.44 + .61	5.49 + .54	5.71 + .39
	0N	5.21 + .65	5.49 + .60	5.50 + .40	5.54 + .57
24 months	-10N	5.43 + .40	5.64 + .40	5.11 + .54	--
	0N	5.30 + .53	5.34 + .47	5.07 + .47	--

^aMean + S.D.; T = temperature abused; N = Not temperature abused.

Table 119. Effect of freezing rate on sensory scores for initial tenderness in ground beef patties with soy following various periods of storage - data adjusted for differences prior to freezing

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing, 1 day	5.82 \pm .16a	5.22 \pm .16ab	5.07 \pm .16ab	4.21 \pm .16b
6 months	5.40 \pm .08a	5.20 \pm .08ab	4.82 \pm .08b	4.91 \pm .08ab
9 months	5.42 \pm .09a	5.16 \pm .09ab	5.03 \pm .09b	4.86 \pm .09b
12 months	5.64 \pm .11a	5.59 \pm .11ab	5.69 \pm .13a	5.13 \pm .11b
24 months	5.63 \pm .085a	5.63 \pm .085a	5.05 \pm .12b	

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

the 0°F in 24 hour rate, initial tenderness decreased with freezing (Table 120). Nontemperature abused, +20°F stored patties had lower initial tenderness than temperature abused patties from all three storage temperatures (Tables 121, 122) following six months of storage.

The various storage time comparisons in Table 123 (mainly immediately post-freezing with some point in storage) indicate a tenderizing effect with storage. Following six months of storage, there were some indications of a higher tenderness with lower storage temperatures and a lower tenderness with higher storage temperatures compared to scores just following freezing (Table 124). After twelve months, patties stored initially at -10 and finally at 0°F and its reciprocal were evaluated as being more tender than patties evaluated right after freezing (Table 125). Also, at twelve months, temperature abused patties increased in tenderness from right after freezing while nonabused patties did not (Table 126). When eighteen months of frozen storage had passed, patties stored at -10°F from the 0°F in 96 hour rate were more tender than those rated just after freezing. This change did not occur for the other freezing rates (Table 127). Between eighteen and twenty-four months, tenderness decreased for the 0°F in 72 hour rate, but not the 0°F in 24 and 48 hour rate (Table 128). Adjusting these data for differences prefreezing did not alter this finding (Table 129).

Values for final tenderness (evaluated at 15 chews) are provided next. Again, there is indication of reduced tenderness for the 0°F in 96 hour rate and some increase in tenderness for the 0°F in 96 hour rate and some increase in tenderness with advancements in storage time (Table 130). Just before and after freezing there were no differences in tenderness due to

Table 120. Interaction effect of storage time (just before and after freezing) and rate of freezing on sensory scores for initial tenderness in ground beef patties with soy

Evaluation time	Freezing Rate, hours to 0°F			
	24	48	72	96
Before freezing	5.75 \pm .17abc	5.87 \pm .17abc	6.05 \pm .17ab	6.37 \pm .17a
Immediately following freezing, 1 day	5.56 \pm .17bcd	5.08 \pm .12de	5.11 \pm .12cde	4.57 \pm .12e

abcde Any mean comparison with different letters is different ($P < .05$).
 Mean \pm S.E.

Table 121. Effect of final storage temperature on sensory scores for initial tenderness in ground beef patties with soy following six months storage

Final Storage Temperature, °F			
-10T	0T	20T	20N
5.20 \pm .061a	5.19 \pm .061a	5.09 \pm .061a	4.85 \pm .061b

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 122. Effect of temperature abuse on sensory scores for initial tenderness in ground beef patties with soy following six months storage

Temperature Abuse	
T	N
5.09a	4.85b

ab Difference between means significant ($P < .05$). Mean. T = temperature abused, N = not temperature abused. Includes just +20°F final storage temperature. S.E. not calculable.

Table 123. Effect of various storage time comparisons on sensory scores for initial tenderness in ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	9 months
4.57 \pm .24b	5.23 \pm .24a
Immediately following freezing, 1 day	12 months
5.08 \pm .12b	5.50 \pm .12a
Immediately following freezing, 1 day	12 months ^C
4.57 \pm .22b	5.37 \pm .22a
9 months	12 months
5.11 \pm .045b	5.52 \pm .047a
Immediately following freezing, 1 day	18 months
5.08 \pm .096b	5.44 \pm .096a

ab Differences between means on the same line are different ($P < .05$); Mean \pm S.E.

^CIncludes just 0°F in 96 hr rate.

Table 124. Effect of storage time (immediately following freezing, six months) on sensory scores for initial tenderness in ground beef patties with soy

		6 months storage					
Immediately following freezing, 1 day	Temperature Abuse	Initial Storage Temperature, °F =					
		Final Storage Temperature, °F =					
		-10	0	20	-10	0	20
5.08 ± .093	T	5.20 ± .093	5.16 ± .093	5.09 ± .093	5.21 ± .093	5.22 ± .093	5.09 ± .09
	N	--	--	4.84 ± .093	--	--	4.87 ± .09

^aDifferences significant (P<.05) by analysis of variance, but not by HSD. Mean ± S.E.
T = Temperature abused; N = Not temperature abused.

Table 125. Effect of storage time (immediately following freezing, twelve months) on sensory scores for initial tenderness in ground beef patties with soy

		12 Months Storage		
Immediately following freezing, 1 day	Initial Storage Temperature, °F =	-10		0
	Final Storage Temperature, °F =	-10	0	-10
5.08 ± .10b		5.50 ± .10ab	5.56 ± .12a	5.55 ± .10a
				5.44 ± .10ab

ab Means on the same line with the same letters are not different ($P > .05$). Mean ± S.E.

Table 126. Effect of storage time (immediately following freezing, twelve months) on sensory scores for initial tenderness in ground beef patties with soy

12 Months Storage			
Immediately following freezing, 1 day	Temperature Abuse	T	N
	Final Storage Temperature, °F =	-10	0
4.57 ± .20b	5.48 ± .14a	5.50 ± .14a	5.23 ± .14ab
			5.25 ± .14ab

ab Means on the same line with different letters are not different ($P > .05$). Mean ± S.E.
Includes just 0°F in 96 hr.

Table 127. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature, final storage temperature, and freezing rate on sensory scores for initial tenderness in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			5.56 ± .17ab	5.08 ± .17ab	5.11 ± .17ab	4.57 ± .17b
18 months	-10	-10	5.22 ± .17ab	5.50 ± .17ab	5.56 ± .17ab	5.71 ± .17a
		0	5.19 ± .17ab	5.56 ± .17ab	5.61 ± .17a	5.50 ± .17ab
	0	-10	5.08 ± .17ab	5.39 ± .17ab	5.42 ± .17ab	5.71 ± .17a
		0	5.22 ± .17ab	5.42 ± .17ab	5.39 ± .17ab	5.58 ± .17ab

ab Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E.

Table 128. Interaction effect of storage time (eighteen, twenty-four months) and rate of freezing on sensory scores for initial tenderness in ground beef patties with soy

Evaluation Time, months	Freezing rate, hours to 0°F		
	24	48	72
18	5.18 \pm .071bc	5.46 \pm .071ab	5.49 \pm .071a
24	5.37 \pm .071abc	5.49 \pm .071a	5.09 \pm .10c

abc Any mean comparison with different letters is different ($P < .05$). Mean \pm S.E.

Table 129. Interaction effect of storage time (eighteen, twenty-four months) and freezing rate on sensory scores for initial tenderness in ground beef patties with soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	5.44 ± .071a	5.60 ± .071a	5.46 ± .071a
24	5.63 ± .071a	5.63 ± .071a	5.06 ± .10b

ab Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E.

Table 130. General table illustrating the sensory scores for final tenderness in ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		6.16 ± .56	6.20 ± .66	6.25 ± .54	6.70 ± .45
Immediately following freezing, 1 day		5.98 ± .70	5.72 ± .69	5.61 ± .72	5.37 ± .71
6 months	-10T	5.86 ± .51	5.61 ± .66	5.60 ± .69	5.88 ± .52
	OT	5.80 ± .54	5.81 ± .58	5.60 ± .62	5.85 ± .60
	20T	5.73 ± .53	5.84 ± .49	5.38 ± .68	5.91 ± .54
	20N	5.47 ± .51	5.50 ± .54	5.02 ± .83	5.73 ± .53
9 months	-10T	5.87 ± .59	5.62 ± .74	5.52 ± .56	5.80 ± .58
	-10N	--	--	--	5.60 ± .60
	OT	5.79 ± .59	5.72 ± .59	5.67 ± .69	5.84 ± .63
	ON	--	--	--	5.90 ± .58
12 months	-10T	6.03 ± .58	6.00 ± .55	6.09 ± .65	5.96 ± .66
	-10N	--	--	--	5.91 ± .53
	OT	5.89 ± .63	5.95 ± .66	6.11 ± .53	6.10 ± .56
	ON	--	--	--	6.04 ± .62
18 months	-10N	5.89 ± .56	6.21 ± .51	6.08 ± .49	6.29 ± .36
	ON	6.04 ± .48	6.28 ± .50	6.07 ± .45	6.12 ± .49
24 months	-10N	6.05 ± .55	6.27 ± .40	5.79 ± .50	--
	ON	5.96 ± .47	5.93 ± .40	5.75 ± .52	--

^aMean ± S.D.; T = temperature abused; N = Not temperature abused.

freezing rate, but there was a reduction in tenderness between these two times for product frozen to 0°F in 96 hours (Table 131). Final tenderness prior to freezing was higher for the 0°F in 96 hour product which necessitated adjustments in some interpretations. After six months, product frozen to 0°F in 72 hours was scored as less tender than the other three rates (Table 132). Adjusting the values for pre-freezing differences resulted in patties from the 0°F in 24 hour rate being more tender than the 0°F in 96 hour rate at six, nine and twelve months (Table 133). After eighteen months, product from the 0°F in 96 hour rate was less tender than patties from the 0°F in 48 hour rate. There were also some additional freezing rate effects on final tenderness at various storage times, but they were always in favor of greater tenderness with faster freezing rates.

As with initial tenderness, nonabused +20°F final stored product at six months had less tenderness than temperature abused patties from the other rates (Table 134, 135).

Increases in storage time produced improvement in final tenderness values (Table 136). Again at twelve months, -10°F initial and 0°F final and its reciprocal generated greater tenderness than just after freezing (Table 137).

Connective tissue values are presented next and wouldn't be expected to be greatly influenced by the study variables (Table 138). Following six months, patties frozen to 0°F in 96 hours exhibited less sensory panel determined connective tissue than patties frozen to 0°F in 72 hours (Table 139). An interaction of before and after freezing with storage time was based on the decreased detectability of connective tissue for 0°F in 72 and 96 hour product, but not the other two rates (Table 140). At six months,

Table 131. Interaction effect of storage time (just before and after freezing) and rate of freezing on sensory scores for final tenderness in ground beef patties with soy

Evaluation time	Freezing Rate, hours to 0°F			
	24	48	72	96
Before freezing	6.16 \pm .16 ab	6.20 \pm .16 ab	6.25 \pm .16 ab	6.70 \pm .16 a
Immediately following freezing, 1 day	5.98 \pm .16 bc	5.72 \pm .11 bc	5.61 \pm .11 bc	5.37 \pm .11 c

abc Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E.

Table 132. Effect of freezing rate on sensory scores for final tenderness in ground beef patties with soy just before freezing and after six months storage

Evaluation time	Freezing Rate, hours to 0°F			
	24	48	72	96
Just before freezing	6.16 \pm .056b	6.20 \pm .056b	6.25 \pm .056b	6.70 \pm .056a
6 months	5.71 \pm .065a	5.69 \pm .065a	5.40 \pm .065b	5.84 \pm .065a

ab Means on the same line with the same letters are not different ($P > .05$).
Mean \pm S.E.

Table 133. Effect of freezing rate on sensory scores for final tenderness in ground beef patties with soy following various periods of storage - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	5.88 \pm .065a	5.82 \pm .065a	5.48 \pm .065b	5.46 \pm .065b
9	6.00 \pm .086a	5.80 \pm .086ab	5.67 \pm .086ab	5.44 \pm .086b
12	6.13 \pm .086a	6.10 \pm .086a	6.18 \pm .086a	5.66 \pm .086b
18	6.13 \pm .080ab	6.37 \pm .080a	6.15 \pm .080ab	5.83 \pm .080b

ab Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E.

Table 134. Effect of final storage temperature on sensory scores for final tenderness in ground beef patties with soy following six months storage

Final Storage Temperature, °F			
-10T	0T	20T	20N
5.74 ± .065a	5.76 ± .065a	5.72 ± .065a	5.43 ± .065b

ab Means on the same line with different letters are different ($P < .05$); Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 135. Effect of temperature abuse on sensory scores for final tenderness in ground beef patties with soy following six months storage

Temperature Abuse	
T	N
5.72a	5.43b

ab Difference between means significant ($P < .05$). Mean. T = temperature abused, N = not temperature abused. Includes just +20°F final storage temperature. S.E. not calculable.

Table 136. Effect of various storage time comparisons on sensory scores for final tenderness in ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	9 months
5.37 \pm .17b	5.78 \pm .17a
Immediately following freezing, 1 day	12 months
5.67 \pm .09b	6.02 \pm .09a
Immediately following freezing, 1 day	12 months ^c
5.37 \pm .12b	6.00 \pm .12a
9 months ^c	12 months ^c
5.78 \pm .06b	6.00 \pm .06a
9 months ^d	12 months ^d
5.73 \pm .04b	6.02 \pm .04a
Immediately following freezing, 1 day	18 months
5.67 \pm .10b	6.12 \pm .10a

ab Differences between means on the same line are significant ($P < .05$).
Mean \pm S.E.

^cIncludes 0°F in 96 hr freezing rate.

^dIncludes just temperature abused product.

Table 137. Effect of storage time (immediately following freezing, twelve months) on sensory scores for final tenderness in ground beef patties with soy

		12 Months Storage		
Immediately following freezing, 1 day	Initial Storage Temperature, °F =	-10		0
	Final Storage Temperature, °F =	-10	0	-10
		5.94 ± .080ab	6.04 ± .092a	6.10 ± .080a
				5.99 ± .080ab

ab Means on the same line with different letters are different ($P < .05$). Mean ± S.E.

Table 138. General table illustrating sensory scores for amount of connective tissue in ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing Rate, hours to 0°F			
		24	48	72	96
Before freezing		6.30 ± .64	6.05 ± .79	6.17 ± .70	6.36 ± .75
Immediately following freezing, 1 day		6.23 ± .77	6.03 ± .92	5.48 ± .82	5.50 ± 1.21
3 months	-10T	5.77 ± .62	5.83 ± .79	5.92 ± .83	6.11 ± .60
	0T	6.08 ± .65	5.97 ± .80	5.81 ± .78	6.03 ± .74
	20T	6.04 ± .65	6.07 ± .74	5.61 ± .90	6.00 ± 1.09
	20N	5.62 ± .78	5.83 ± .74	5.27 ± 1.00	6.11 ± .77
9 months	-10T	5.83 ± .69	5.97 ± .76	5.61 ± 1.04	6.20 ± .59
	-10N	--	--	--	5.70 ± .75
	0T	5.81 ± .63	6.00 ± .77	5.66 ± .95	5.92 ± .70
	0N	--	--	--	5.90 ± .67
12 months	-10T	6.16 ± .64	6.20 ± .63	6.14 ± .67	6.20 ± .75
	-10N	--	--	--	6.32 ± .56
	0T	6.17 ± .64	6.03 ± .67	6.32 ± .66	6.33 ± .72
	0N	--	--	--	6.36 ± .59
18 months	-10N	6.37 ± .59	6.53 ± .53	6.44 ± .41	6.56 ± .50
	0N	6.37 ± .61	6.61 ± .49	6.53 ± .43	6.58 ± .65
24 months	-10N	6.27 ± .46	6.50 ± .41	6.12 ± .45	--
	0N	6.30 ± .37	6.37 ± .42	6.05 ± .35	--

^aMean ± S.D. T = temperature abused; N = not temperature abused.

Table 139. Effect of freezing rate on sensory scores for amount of connective tissue in ground beef patties with soy following various storage periods

Evaluation Time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing, 1 day ^a	6.23 ± .12	6.03 ± .12	5.48 ± .12	5.50 ± .12
6 months	5.89 ± .07bc	5.92 ± .07bc	5.65 ± .07 c	5.66 ± .07b

^aRate effect significant (P<.05) by analysis of variance (P<.05) but not by HSD.

^bMeans on the same line with different letters are different (P<.05).

Mean ± S.E.

Table 140. Interaction effect of storage time (just before and after freezing) and freezing rate on sensory scores for amount of connective tissue in ground beef patties with soy

Evaluation Time	Freezing rate, hours to 0°F			
	24	48	72	96
before freezing	6.30 \pm .11a	6.05 \pm .11a	6.17 \pm .11a	5.36 \pm .11a
Immediately following freezing, 1 day	6.23 \pm .11a	6.03 \pm .078a	5.48 \pm .078b	5.50 \pm .078b

ab Any mean comparison with the same letters is not different ($P > .05$).

Mean \pm S.E.

nonabused product was rated as having less connective tissue than temperature abused product (Table 141). While a significant initial-final storage temperature freezing rate interaction was detected following nine months, the single difference followed no logical pattern (Table 142).

As storage time progressed, for some reason less connective tissue was detected by the sensory panel compared to just post-freezing (Table 143). This appeared to be true at nine months for patties frozen to 0°F in 96 hours, but not for patties frozen to 0°F in 24 hours (Table 144). Between nine and twelve months, less detectable connective tissue was found for both the 0°F in 24 and 72 hour freezing rates but not the 0°F in 48 and 96 hour rate (Table 145). For -10°F final temperature stored product, this reduced detectability of connective tissue between nine and twelve months was true only for nonabused product (Table 146). After twelve months of storage, patties stored both initially and finally at 0°F were rated as having less connective tissue than just after freezing if the patties had been frozen to 0°F in 72 or 96 hours (Table 147). In the case of eighteen months of storage, for both of these freezing rates, less connective tissue was found after storage compared to just post-freezing, regardless of initial-final temperature combinations (Table 148). There were again indications of this trend following twenty-four months of storage, but no differences exceeded the HSD value (Table 149).

General values for Instron peak load are provided in Table 150. Both 0°F in 24 and 96 hour rates produced lower values (greater tenderness). These rate effect differences seemed to be extended out into storage. However, this trend was noted even before the products were frozen. After all storage times (and even before freezing), product frozen to 0°F in

Table 141. Effect of temperature abuse on sensory scores for amount of connective tissue in ground beef patties with soy following six months storage

Temperature Abuse	
T	N
5.94a	5.71b

ab Difference between means significant ($P < .05$). Mean. T = temperature abused, N = not temperature abused. S.E. not calculable.

Table 142. Interaction effect of initial storage temperature, final storage temperature and rate of freezing on sensory scores for amount of connective tissue in ground beef patties with soy following nine months of storage

Initial storage temperature, °F	Final storage temperature, °F	Freezing Rate, hours to 0°F			
		24	48	72	96
-10	-10	5.92 + .13ab	6.09 + .13ab	5.47 + .13b	6.22 + .13ab
	0	5.71 ± .13ab	5.75 ± .13ab	5.78 ± .13ab	5.78 ± .13ab
0	-10	5.75 + .13ab	5.84 + .13ab	5.75 + .13ab	6.19 + .13ab
	0	5.92 ± .13ab	6.25 ± .13a	5.53 ± .13ab	6.05 ± .13ab

ab Any mean comparison with the same letter is not different ($P>.05$). Mean ± S.E.

Table 143. Effect of various storage time comparisons on sensory scores for amount of connective tissue in ground beef patties with soy

Evaluation Times	
Immediately following freezing, 1 day	9 months
5.50 \pm .17b	5.93 \pm .17a
Immediately following freezing, 1 day	12 months ^c
5.81 \pm .078b	6.19 \pm .078a
Immediately following freezing, 1 day	12 months ^d
5.50 \pm .073b	6.30 \pm .073a
Immediately following freezing, 1 day	18 months
5.81 \pm .073b	6.50 \pm .073a
Immediately following freezing, 1 day	24 months
5.91 \pm .095b	6.28 \pm .095a
18 months	24 months
6.48 \pm .03a	6.27 \pm .03b

ab Differences between means on the same line significant ($P < .05$).
Mean \pm S.E.

^cIncludes just temperature abused product.

^dIncludes just 0°F in 96 hr freezing rate product.

Table 144. Interaction effect of storage time (immediately following freezing, nine months), initial storage temperature, final storage temperature and freezing rate on sensory scores for amount of connective tissue in ground beef patties with soy^a

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
9 months	-10		6.23 ± .14	6.03 ± .14	5.48 ± .14	5.50 ± .14
		-10	5.92 ± .14	6.09 ± .14	5.47 ± .14	6.22 ± .14
	0	0	5.71 ± .14	5.75 ± .14	5.78 ± .14	5.78 ± .14
	0		5.75 ± .14	5.84 ± .14	5.75 ± .14	6.19 ± .14
		-10	5.92 ± .14	6.25 ± .14	5.53 ± .14	6.06 ± .14
	0	0				

^aInteraction effect significant ($P < .05$) by analysis of variance, but not by HSD. Mean ± S.E.

Table 145. Interaction effect of storage time (nine, twelve months) and freezing rate on sensory scores for amount of connective tissue in ground beef patties with soy

Evaluation Time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	5.83 \pm .06bc	5.98 \pm .06ab	5.63 \pm .06c	6.06 \pm .06ab
12	6.16 \pm .06a	6.12 \pm .06ab	6.20 \pm .06a	6.27 \pm .06a

abc Any mean comparison with different letters is different ($P < .05$).
 mean \pm S.E.

Table 146. Interaction effect of storage time (nine, twelve months), temperature abuse and final storage temperature on sensory scores for amount of connective tissue in ground beef patties with soy

Evaluation time, months	Temperature abuse	Final Storage Temperature, °F	
		-10	0
9	T	6.20 \pm .085a	5.92 \pm .085ab
	N	5.70 \pm .085b	5.90 \pm .085ab
12	T	6.20 \pm .085a	6.33 \pm .085a
	N	6.32 \pm .085a	6.36 \pm .085a

ab Any mean comparisons with different letters are different ($P < .05$). Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 147. Interaction effect of storage time (immediately following freezing, twelve months), initial storage temperature, final storage temperature and rate of freezing on sensory scores for amount of connective tissue in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			6.23 + .14ab	6.03 + .14ab	5.48 + .14b	5.50 + .14b
12 months	-10	-10	6.06 + .14ab	6.25 + .14ab	5.97 + .14ab	6.19 + .14ab
		0	6.31 + .14ab	6.00 + .14ab	6.25 + .21ab	6.30 + .14ab
	0	-10	6.25 + .14ab	6.10 + .14ab	6.31 + .14ab	6.21 + .14ab
		0	6.03 + .14ab	6.06 + .14ab	6.37 + .14a	6.36 + .14a

ab Any mean comparison with the same letter is not different ($P>.05$); mean + S.E.

Table 148. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature, final storage temperature and rate of freezing on sensory scores for amount of connective tissue in ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
	-10		6.23 ± .13ab	6.03 ± .13ab	5.43 ± .13b	5.50 ± .13b
		-10	6.44 ± .13a	6.53 ± .13a	6.44 ± .13a	6.42 ± .13a
18 months	0	0	6.44 ± .13a	6.61 ± .13a	6.58 ± .13a	6.54 ± .13a
	0	-10	6.31 ± .13a	6.53 ± .13a	6.44 ± .13a	6.75 ± .13a
		0	6.31 ± .13a	6.61 ± .13a	6.47 ± .13a	6.62 ± .13a

: ab Any mean comparison with the same letter is not different ($P > .05$); mean ± S.E.

Table 149. Effect of storage time (immediately following freezing, twenty-four months) on sensory scores for amount of connective tissue in ground beef patties with soya^a

		24 months storage	
Immediately following freezing, 1 day	Initial Storage Temperature, °F =	-10	0
	Final Storage Temperature, °F =	0	-10
		6.29 ± .10	6.30 ± .084
		6.31 ± .084	6.19 ± .10

^aDifferences significant ($P < .05$) by analysis of variance, but not by HSD. Mean ± S.E.

Table 150. General table illustrating Instron peak load values for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		3.76 ± 1.15	4.37 ± .99	5.48 ± 1.63	3.67 ± 1.01
Immediately following freezing, 1 day		5.12 ± 1.42	6.11 ± 1.27	7.38 ± 1.65	5.02 ± 1.12
6 months	-10T	5.41 ± 1.14	5.57 ± 1.18	7.70 ± 1.70	5.54 ± 1.34
	0T	5.27 ± 1.19	5.50 ± 1.14	8.51 ± 1.89	6.29 ± 1.41
	20T	5.64 ± 1.40	5.60 ± .79	8.39 ± 2.29	6.23 ± 1.07
	20N	6.16 ± 1.12	6.02 ± .98	7.79 ± 2.17	5.51 ± .86
9 months	-10T	5.35 ± 1.03	5.93 ± 1.11	7.58 ± 1.49	5.85 ± 1.17
	-10N				5.87 ± 1.24
	0T	5.80 ± 1.37	6.55 ± 1.34	7.58 ± 1.39	5.94 ± .96
	0N				5.61 ± 1.22
12 months	-10T	5.19 ± 1.24	5.60 ± .89	7.25 ± 1.54	5.52 ± 1.23
	-10N				5.94 ± 1.16
	0T	5.49 ± .97	5.71 ± .89	6.99 ± 1.46	5.51 ± .79
	0N				5.54 ± 1.16
18 months	-10N	5.63 ± .99	5.71 ± .98	7.34 ± 1.52	5.43 ± 1.18
	0N	5.46 ± 1.02	5.46 ± .96	7.57 ± 1.49	5.43 ± .75
24 months	-10N	5.34 ± 1.14	4.97 ± .77	6.15 ± 1.36	
	0N	5.46 ± 1.25	5.28 ± .78	6.40 ± 1.54	

^a Mean ± S.D. T = temperature abused, N = not temperature abused.

72 hours had higher Instron peak load values than the 0°F in 24 and 96 hour rates. At all but the immediately post-freezing time, the 0°F in 72 hour rate also had higher values than the 0°F in 48 hour rates (Table 151). However, adjusting these freezing rate data for differences prior to freezing eliminated many of the significant effects due to rate (Table 152). Values for the 0°F in 48 hour freezing rate were lowest, but not always significantly ($P < .05$) so from the other rates. For patties frozen to 0°F in 96 hours, after twelve months of storage, temperature abuse decreased peak load values for patties initially stored at -10°F and increased values for 0°F stored product (Table 153).

Except for freezing itself (which increased peak load values), advancements in storage where significant, decreased peak load values (Table 154). After six months of storage and for the 0°F in 48 hour freezing rate, only final storage at both 0°F and -10°F increased peak load values to those reported right after freezing (Table 155). Between nine and twelve months, temperature abuse showed indication of increasing peak load values, but decreasing other (Table 156). Between right after freezing and twelve months, values increased for 0°F in 72 hour frozen product stored initially at -10°F and finally at 0°F (Table 157, 158). Between twelve and eighteen months of storage, Instron peak load values decreased in patties which were initially stored at -10°F; no differences were detected if initial storage was at 0°F (Table 159).

Instron Newton values showed very similar trends to that noted for peak load values. In other words, values were highest for the 0°F in 72 hour rate. Storage didn't seem to appreciably alter or change values greatly (Table 160). Like peak load, the biggest change in Newtons seemed

Table 151. Effect of freezing rate on Instron peak load values for ground beef patties with soy following various storage periods

Evaluation time	Freezing rate, hours to 0°F		
	24	48	96
Immediately before freezing	3.76 + .18b	4.37 + .18b	5.48 + .18a
Immediately following freezing, 1 day	5.12 + .31b	6.11 + .31ab	7.38 + .31a
6 months	5.62 + .19b	5.67 + .19b	8.10 + .19a
9 months	5.57 + .24b	6.24 + .24b	7.58 + .24a
12 months	5.34 + .14b	5.66 + .14b	7.12 + .16a
18 months	5.55 + .17b	5.59 + .17b	7.45 + .17a
24 months	5.40 + .18b	5.12 + .18b	6.27 + .25a

ab Means on the same line with different letters are different ($P < .05$).
Mean + S.E.

Table 152. Effect of freezing rate on Instron peak load values for ground beef patties with soy following various periods of storage -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	6.18 \pm .19bc	5.62 \pm .19c	6.94 \pm .19a	6.54 \pm .19ab
18	6.11 \pm .17ab	5.53 \pm .17b	6.29 \pm .17a	6.07 \pm .17ab
24	5.96 \pm .18a	5.07 \pm .18b	5.11 \pm .25b	

abc Means on the same line with different letters are different (P<.05). Mean \pm S.E.

Table 153. Interaction effect of temperature abuse and initial storage temperature on Instron peak load values for ground beef patties with soy following twelve months storage^a

Temperature abuse	Initial storage temperature, °F	
	-10	0
T	5.23 \pm .16	5.80 \pm .16
N	5.96 \pm .16	5.52 \pm .16

^a Interaction effect significant ($P < .05$) by analysis of variance, but not by HSD. Includes only 0°F in 96 hr rate. T = temperature abuse, N = not temperature abused.

Table 154. Effect of various storage time comparisons on Instron peak load values for ground beef patties with soy

<u>Evaluation time</u>	
<u>Immediately before freezing</u>	<u>Immediately following freezing, 1 day</u>
4.32 ± .14b	5.91 ± .11a
<u>9 months</u>	<u>12 months</u>
6.32 ± .11a	5.91 ± .11b
<u>Immediately following freezing, 1 day</u>	<u>24 months</u>
6.20 ± .21a	5.52 ± .21b
<u>18 months</u>	<u>24 months</u>
6.20 ± .09a	5.64 ± .09b

ab Differences between means on the same line are significant ($P < .05$).
Mean ± S.E.

Table 155. Interaction effect of storage time (immediately following freezing, six months), initial and final storage temperatures and freezing rate on Instron peak load values for ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
6 months	-10	-10	6.86 ± .39g	8.19 ± .39abcdefg	7.25 ± .39fg	9.96 ± .39abcd
			7.54 ± .39efg	10.10 ± .39abc	8.40 ± .39abcdefg	8.85 ± .39abcdef
			6.80 ± .39g	9.61 ± .39abcde	8.19 ± .39abcdefg	8.12 ± .39bcdefg
			7.63 ± .39defg	8.96 ± .39abcdefg	8.53 ± .39abcdefg	8.52 ± .39abcdef
			7.63 ± .39defg	8.12 ± .39bcdefg	8.65 ± .39abcdefg	8.85 ± .39abcdef
	0	0	8.26 ± .39abcdefg	10.26 ± .39ab	8.28 ± .39abcdefg	7.89 ± .39cdefg
			7.10 ± .39fg	10.50 ± .39a	8.00 ± .39bcdefg	8.60 ± .39abcdef
			9.00 ± .39abcdefg	9.21 ± .39abcdef	8.79 ± .39abcdefg	8.68 ± .39abcdef
			7.67 ± .39defg	8.57 ± .39abcdefg	8.66 ± .39abcdefg	8.54 ± .39abcdef

abcdefg Any mean comparison with different letters is different (P<.05). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 156. Interaction effect of storage time (nine, twelve months), temperature abuse and initial storage temperature on Instron peak load values for ground beef patties with soy^a

Evaluation time, months	Temperature abuse	Initial storage temperature, °F	
		-10	0
9	T	5.98 \pm .20	5.80 \pm .20
	N	5.56 \pm .20	5.91 \pm .20
12	T	5.23 \pm .20	5.80 \pm .20
	N	5.96 \pm .20	5.52 \pm .20

^a Interaction effect significant ($P < .05$) by analysis of variance, but not by HSD. Mean \pm S.E. Includes only the 0°F in 96 hr rate. T = temperature abused, N = not temperature abused.

Table 157. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature and rate of freezing on Instron peak load values for ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10	-10T	6.86 + .35ef	8.19 + .35abcdef	7.25 + .35cdef	9.96 + .35a
		OT	7.42 + .35cdef	9.53 + .35ab	9.02 + .35abcd	8.46 + .35abcdef
		ON	6.76 + .35f	8.88 + .35abcde	9.59 + .35ab	8.78 + .35abcdef
	0	-10T	7.53 + .35bcdef	8.00 + .35abcdef	8.18 + .35abcdef	8.64 + .35abcdef
		OT	6.92 + .35ef	9.20 + .35abc	9.32 + .35abc	8.61 + .35abcdef
		ON	6.96 + .35def	8.68 + .35abcdef	8.50 + .35abcdef	9.15 + .35abc
		OT	7.70 + .35bcdef	8.17 + .35abcdef	9.16 + .35abc	9.07 + .35abc
		ON				

abcdef Any mean comparison with different letters is different ($P < .05$). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 158. Interaction effect of storage time (Immediately following freezing, twelve months), temperature abuse, final storage temperature and rate of freezing on Instron peak load values for ground beef patties with soy

Evaluation time	Temperature abuse	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	T	-10	6.86 + .33de	8.19 + .33abcde	7.25 + .33cde	9.96 + .33a
		0	7.42 + .33cde 6.76 + .33e	9.53 + .33ab 8.88 + .33abc	9.02 + .33abc 9.59 + .33ab	8.46 + .33abcde 8.78 + .33abcd
	N	-10	7.35 + .33cde	8.28 + .33abcde	8.46 + .33abcde	8.76 + .33abcd
		0	7.52 + .33cde	8.00 + .33bcde	8.18 + .33abcde	8.64 + .33abcde

abcde Any mean comparison with different letters is different ($p < .05$). Mean ± S.E. T = temperature abused, N = not temperature abused. Includes just -10°F initial storage temperature.

Table 159. Interaction effect of storage time (twelve, eighteen months) and initial storage temperature on Instron peak load values for ground beef patties with soy

Evaluation time, months	Initial storage temperature, °F	
	-10	0
12	5.96 \pm .11a	5.52 \pm .11ab
18	5.20 \pm .11b	5.65 \pm .11ab

ab Any mean comparison with the same letters is not different ($P > .05$).

Mean \pm S.E. Includes only nonabused 0°F in 96 hr product.

Table 160. General table illustrating Instron Newton values for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		11.25 + <u>3.44</u>	13.10 + <u>3.03</u>	16.18 + <u>4.70</u>	10.49 + <u>2.87</u>
Immediately following freezing, 1 day		16.72 + <u>4.70</u>	21.56 + <u>4.71</u>	25.77 + <u>6.25</u>	17.36 + <u>4.11</u>
	6 months				
	-10T	19.66 + <u>4.78</u>	20.57 + <u>4.94</u>	26.97 + <u>6.66</u>	19.40 + <u>4.99</u>
	OT	18.14 + <u>4.48</u>	20.64 + <u>4.90</u>	30.70 + <u>7.15</u>	22.37 + <u>6.10</u>
9 months	20T	20.49 + <u>6.03</u>	20.83 + <u>3.01</u>	30.97 + <u>8.64</u>	22.01 + <u>3.81</u>
	20N	22.66 + <u>4.03</u>	22.38 + <u>4.36</u>	27.76 + <u>7.75</u>	20.30 + <u>3.53</u>
	-10T	17.86 + <u>3.45</u>	19.89 + <u>3.86</u>	25.83 + <u>5.35</u>	18.93 + <u>3.62</u>
	-10N	19.40 + <u>4.73</u>	22.58 + <u>4.41</u>	26.33 + <u>4.98</u>	19.38 + <u>4.39</u>
12 months	OT				19.52 + <u>2.98</u>
	ON				18.66 + <u>3.89</u>
	-10T	14.32 + <u>3.39</u>	15.79 + <u>2.54</u>	27.58 + <u>5.54</u>	19.05 + <u>4.05</u>
	-10N				19.82 + <u>4.32</u>
18 months	OT	14.98 + <u>2.44</u>	15.90 + <u>2.52</u>	23.72 + <u>5.19</u>	19.65 + <u>2.97</u>
	ON				18.81 + <u>3.77</u>
	-10N	19.30 + <u>3.15</u>	20.63 + <u>3.43</u>	26.24 + <u>5.57</u>	20.19 + <u>4.56</u>
	ON	18.58 + <u>3.31</u>	19.82 + <u>3.60</u>	27.72 + <u>5.69</u>	20.76 + <u>3.17</u>
24 months	-10N	19.91 + <u>4.49</u>	18.13 + <u>2.66</u>	22.16 + <u>4.82</u>	
	ON	21.01 + <u>5.46</u>	19.44 + <u>2.92</u>	22.40 + <u>5.42</u>	

^a Mean + S.D. T = temperature abused, N = not temperature abused.

to be simply due to freezing. The effects of freezing rate on Newton values were similar to that for peak load; in that at most storage times the 0°F in 72 hour rate produced higher Newton values than the other three rates (Table 161). Thus, it would appear that differences between patties within or between treatments was exerting very minor effects on Instron values. Adjusting the data for prefreezing differences (Table 162) resulted in many of the differences in Newton values between the 0°F in 72 and 96 hour rates to be nonsignificant ($P>.05$). After twelve months of storage, -10°F initial storage produced lower Newton values than 0°F (Table 163). There were some indications after twelve months that temperature abuse increased Newton values for patties stored at 0°F, while the opposite occurred for -10°F stored patties (Table 164).

Storage up to six months increased, Newton values overall, while the opposite occurred to twelve months storage (Table 165). Between nine and twelve months, Newton values decreased for 0°F in 24 and 48 hour rates, but did not change for the other two rates (Table 166). The 0°F in 72 hour rate had the highest values. Adjusting these data for pre-freezing differences resulted in no differences between freezing rates at nine months (Table 167). There were also some indications of inconsistent trends respective to temperature abuse, initial storage temperature and storage time (nine vs twelve months - Table 168). The higher values for Newtons for the 0°F in 72 hour rate noted right after freezing was also observed for all treatment combinations at twelve months (Table 169). Adjusting these data for differences, pre-freezing did not appreciably alter these differences (Table 170). Between twelve and eighteen months there were indications (not significant, $P<.05$, by HSD) that values went

Table 161. Effect of freezing rate on Instron Newton values for ground beef patties with soy following various storage times

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	11.25 \pm .52b	13.10 \pm .52b	16.18 \pm .52a	10.49 \pm .52b
After freezing, 1 day	16.72 \pm 1.15b	21.56 \pm 1.15ab	25.77 \pm 1.15a	17.36 \pm 1.15b
6 months	20.24 \pm .84b	21.10 \pm .84b	29.10 \pm .84a	21.02 \pm .84b
9 months	18.63 \pm .82b	21.24 \pm .82b	26.08 \pm .82a	19.23 \pm .82b
12 months	14.65 \pm .45c	15.85 \pm .45c	26.65 \pm .56a	19.35 \pm .45b
18 months	18.94 \pm .59b	20.22 \pm .59b	26.98 \pm .59a	20.47 \pm .59b
24 months	20.46 \pm .63ab	18.79 \pm .63b	22.28 \pm .89a	

abc Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E.

Table 162. Effect of freezing rate on Instron Newton values for ground beef patties with soy following various storage periods -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	21.74 \pm .84b	20.76 \pm .84b	25.67 \pm .84a	23.28 \pm .84ab
12	16.16 \pm .45b	15.50 \pm .45b	22.22 \pm .56a	21.62 \pm .45a
18	20.44 \pm .59bc	19.88 \pm .59c	23.55 \pm .59a	22.74 \pm .59ab
24	21.96 \pm .63a	18.45 \pm .63b	18.85 \pm .89b	

abc Means on the same line with different letters are different (P<.05). Mean \pm S.E.

Table 163. Effect of initial storage temperature on Instron Newton values for ground beef patties with soy following twelve months storage

Initial storage temperature, °F	
-10	0
18.10 \pm .35b	19.65 \pm .35a

ab Difference between means significant ($P < .05$). Mean \pm S.E.

Table 164. Interaction effect of temperature abuse and initial storage temperature on Instron Newton values for ground beef patties with soy following twelve months storage

Temperature abuse	Initial storage temperature, °F	
	-10	0
T	18.50 \pm .53	20.21 \pm .53
N	20.35 \pm .53	18.29 \pm .53

^a Interaction significant ($P < .05$) by analysis of variance but not by HSD. Mean \pm S.E. T = temperature abused, N = not temperature abused. Includes just 0°F in 96 hr rate.

Table 165. Effect of various storage time comparisons on Instron Newton values for ground beef patties with soy

Evaluation time	
Before freezing	Immediately following freezing, 1 day
12.76 \pm .48b	20.35 \pm .38a
Immediately following freezing, 1 day	6 months
20.35 \pm 1.19b	22.86 \pm 1.19a
Immediately following freezing, 1 day	12 months
20.35 \pm .58a	18.45 \pm .58b

ab Differences between means on the same line are significant ($P < .05$).
Mean \pm S.E.

Table 166. Interaction effect of storage time (nine, twelve months) and freezing rate on Instron Newton values for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	18.63 \pm .66bc	21.24 \pm .66b	26.08 \pm .66a	19.23 \pm .66bc
12	14.65 \pm .66d	15.85 \pm .66cd	26.04 \pm .94a	19.35 \pm .66b

abcd Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 167. Interaction effect of storage time (nine, twelve months) and freezing rate on Instron Newton values for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	20.14 \pm .66a	20.89 \pm .66a	22.65 \pm .66a	21.49 \pm .66a
12	16.16 \pm .66b	15.50 \pm .66b	22.61 \pm .94a	21.62 \pm .66a

ab Any mean comparison with the same letter is not different
($P > .05$). Mean \pm S.E.

Table 168. Interaction effect of storage time (nine, twelve months), temperature abuse and initial storage temperature on Instron Newton values for ground beef patties with soy^a

Evaluation time, months	Temperature abuse	Initial storage temperature, °F	
		-10	0
9	T	19.61 + .54	18.84 + .54
	N	17.40 + .76	19.99 + .54
12	T	18.50 + .54	20.21 + .54
	N	20.35 + .54	18.29 + .54

^a Interaction significant ($P < .05$) by analyses of variance, but not by HSD. Mean + S.E. T = temperature abused, N = not temperature abused. Includes just 0°F in 96 hr freezing rate.

Table 169. Interaction effect of storage time (immediately following freezing, twelve months) initial storage temperature, final storage temperature and freezing rate on Instron Newton values for ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
			16.72 + 1.04cdef	21.56 + 1.04bcd	25.77 + 1.04ab	17.36 + 1.04cdef
12 months	-10	-10	13.48 + 1.04f	15.75 + 1.04cdef	25.96 + 1.04ab	18.06 + 1.04cdef
	0	0	14.91 + 1.04ef	16.35 + 1.04cdef	21.63 + 1.59bc	18.93 + 1.04cdef
	0	-10	15.16 + 1.04cdef	15.84 + 1.04cdef	28.93 + 1.59a	20.04 + 1.04bcde
		0	15.05 + 1.04def	15.45 + 1.04cdef	26.10 + 1.04ab	20.37 + 1.04bcde

abcdef Any mean comparison with different letters is different (P<.05). Mean + S.E.

Table 170. Interaction effect of storage time (immediately following freezing, twelve months), initial storage temperature, final storage temperature and rate of freezing on Instron Newton values for ground beef with soy -- data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following, freezing, 1 day						
			18.22 ± 1.04bcd	21.22 ± 1.04abcd	22.34 ± 1.04abc	19.63 ± 1.04abcd
12 months	-10	-10	14.98 ± 1.04d	15.40 ± 1.04d	22.53 ± 1.04ab	20.32 ± 1.04abcd
	0	0	16.42 ± 1.04bcd	16.00 ± 1.04cd	18.20 ± 1.59bcd	21.20 ± 1.04abcd
	0	-10	16.66 ± 1.04bcd	15.50 ± 1.04d	25.50 ± 1.59a	22.31 ± 1.04abc
		0	16.55 ± 1.04bcd	15.11 ± 1.04d	22.67 ± 1.04ab	22.64 ± 1.04ab

abcd Any mean comparison with the same letters is not different (P>.05). Mean ± S.E.

down for patties initially stored at -10°F and went up for patties stored at 0°F (Table 171). There was a substantial drop in Newton values between eighteen and twenty-four months for patties frozen to 0°F in 72 hours (Table 172, 173).

General values for Instron modulus are provided in Table 174. Higher modulus values reflect greater stress or load in relation to peak elongation or strain. Freezing produced the greatest increase in modulus values. Increases in both storage time and the use of $+20^{\circ}\text{F}$ increased modulus values.

The 0°F in 72 hour rate was the only one not to show increased modulus values as a result of freezing (Table 175). Just before freezing the 0°F in 24 hour rate formulation produced the highest modulus values, while after eighteen months of storage the two faster rates yielded higher Instron modulus values than the two slower rates (Table 176). Adjusting these pre-freezing differences didn't change the eighteen month freezing rate differences except to make the values higher for 0°F in 24 vs 0°F in 48 hour rate. However, the 0°F in 24 and 48 hour rates now produced higher modulus values at twenty-four months than the 0°F in 72 hour rate (Table 177).

At just six months of storage, -10 and 0°F storage temperatures had lower modulus values than the $+20^{\circ}\text{F}$ storage temperature (Table 178). At the nine month storage interval, temperature abuse substantially increased the modulus values (Table 179). The 0°F in 96 hour rate created higher modulus values than the other two rates following nine months when -10°F storage was employed; use of 0°F storage produced no freezing rate effect on modulus at this storage time (Table 180). At twelve months of storage, the use of 0°F produced higher values than -10°F final storage (Table 181).

Table 171. Interaction effect of storage time (twelve, eighteen months) and initial storage temperature on Instron Newton values for ground beef patties with soy^a

Evaluation time, months	Initial storage temperature, °F	
	-10	0
12	20.35 \pm .57	18.29 \pm .57
18	19.65 \pm .57	21.30 \pm .57

^a Interaction significant ($P < .05$) by analyses of variance, but not by HSD.
Mean \pm S.E. Includes just 0°F in 96 hr rate.

Table 172. Interaction effect of storage time (eighteen, twenty-four months) and freezing rate on Instron Newton values for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	18.94 \pm .50c	20.22 \pm .50bc	26.98 \pm .50a
24	20.46 \pm .50bc	18.79 \pm .50c	22.29 \pm .71b

abc Any mean comparison with different letters is not different ($P > .05$).
Mean \pm S.E.

Table 173. Interaction effect of storage time (eighteen, twenty-four months) and freezing rate on Instron Newton values for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	20.44 \pm .50bc	19.88 \pm .50bc	23.55 \pm .50a
24	21.96 \pm .50ab	18.45 \pm .50c	18.86 \pm .71c

abc Any mean comparisons with different letters is different (P<.05). Mean \pm S.E. Includes just nonabused product.



Table 174. General table illustrating Instron modulus values for ground beef patties with soy throughout storage according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		19.32 \pm 2.11	22.72 \pm 2.27	24.97 \pm 2.98	20.15 \pm 3.21
Immediately following freezing, 1 day		27.49 \pm 3.37	28.28 \pm 3.60	27.31 \pm 3.13	28.04 \pm 3.93
3 months	-10	31.91 \pm 3.79	34.55 \pm 3.45	32.84 \pm 3.54	29.64 \pm 5.80
	0	34.73 \pm 4.37	32.70 \pm 4.08	31.08 \pm 4.44	30.32 \pm 3.90
	20T	34.81 \pm 3.24	36.03 \pm 3.83	35.77 \pm 4.78	35.18 \pm 5.21
	20N	36.78 \pm 4.64	36.87 \pm 4.56	34.72 \pm 4.34	35.31 \pm 3.99
6 months	-10T	36.01 \pm 3.86	36.19 \pm 3.84	35.70 \pm 4.11	39.91 \pm 4.84
	-10N	--	--	--	34.99 \pm 4.67
	0T	34.59 \pm 4.44	35.70 \pm 4.96	38.07 \pm 4.37	41.29 \pm 4.63
	0N	--	--	--	31.01 \pm 3.93
9 months	-10T	35.74 \pm 4.25	36.71 \pm 3.73	36.54 \pm 4.08	37.62 \pm 4.15
	-10N	--	--	--	39.66 \pm 5.54
	0T	36.65 \pm 4.10	37.88 \pm 5.13	37.07 \pm 4.28	41.33 \pm 5.72
	0N	--	--	--	38.60 \pm 3.69
12 months	-10N	42.55 \pm 3.89	40.32 \pm 4.61	34.99 \pm 4.91	32.64 \pm 3.45
	0N	41.66 \pm 4.94	40.21 \pm 5.00	35.54 \pm 3.67	34.58 \pm 3.96
15 months	-10N	38.14 \pm 9.87	38.94 \pm 6.01	38.36 \pm 7.99	--
	0N	40.44 \pm 8.05	44.30 \pm 7.88	33.03 \pm 10.86	--

-- = no data; \pm S.D.; T = Temperature abused; N = Not temperature abused.

Table 175. Interaction effect of storage time (before and after freezing) and freezing rate on Instron modulus values for ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	19.32 + 1.10d	22.72 + 1.10bcd	24.97 + 1.10abc	20.15 + 1.10cd
Immediately following freezing, 1 day	27.49 + 1.10ab	28.28 + .78a	27.31 + .78ab	28.04 + .78a

abcd Any mean comparison with different letters is different ($P < .05$); mean + S.E.

Table 176. Effect of freezing rate on Instron modulus values for ground beef patties with soy following various storage periods

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing	19.32 \pm .63b	22.72 \pm .63ab	24.97 \pm .63a	20.15 \pm .63b
18 months	42.10 \pm .86a	40.27 \pm .86a	35.26 \pm .86b	33.61 \pm .86b

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 177. Effect of freezing rate on Instron modulus values for ground beef patties with soy following various storage periods -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	38.07 \pm .97ab	36.36 \pm .97ab	33.62 \pm 1.12b	41.12 \pm .97a
18	44.57 \pm .86a	39.34 \pm .86b	32.08 \pm .86c	35.25 \pm .86c
24	41.76 \pm 1.32a	40.69 \pm 1.32a	32.51 \pm 1.87b	

abc Means on the same line with different letters are different (P<.05). Mean \pm S.E.

Table 178. Effect of final storage temperature on Instron modulus values for ground beef patties with soy following six months storage

Final Storage Temperature, °F			
-10T	0T	20T	20N
32.23 \pm .69b	32.21 \pm .69b	35.45 \pm .69a	35.92 \pm .69a

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused.

Table 179. Effect of temperature abuse on Instron modulus values for ground beef patties with soy following nine months storage

Temperature Abuse	
T	N
40.60 \pm 1.00a	33.0 \pm 1.00b

ab Difference between means significant ($P < .05$); Mean \pm S.E. Includes only 0°F in 96 hr product; T = Temperature abused; N = Not temperature abused.

Table 180. Interaction effect of initial storage temperature and rate of freezing on Instron modulus values for ground beef patties with soy following nine months storage

Initial storage temperature, (°F)	Freezing rate, hours to 0°F			
	24	48	72	96
-10	34.17 ± .78c	35.75 ± .78bc	36.84 ± .78bc	42.03 ± .78a
0	36.44 ± .78bc	36.14 ± .78bc	36.93 ± .78bc	39.16 ± .78ab

abc Any mean comparison with the same letters is not different ($P > .05$); Mean ± S.E.

Table 181. Effect of final storage temperature on Instron modulus values for ground beef patties with soy following twelve months storage

Final Storage Temperature, °F	
-10	0
36.65 \pm .44b	38.24 \pm .48a

ab Difference between means
significant ($P < .05$);
Mean \pm S.E.

For just the 0°F in 96 hour rate following twelve months, there was some evidence that changing temperatures from the initial to final storage phases produced decreases in modulus values (Table 182). Again at this rate and for just the 0°F in 96 hour rate, temperature abuse produced a decrease in modulus values if the initial storage temperature was -10°F, while an increase was produced for patties initially stored at 0°F (Table 183).

In comparison with immediately following freezing, storage time advancements always produced increased modulus values (Table 184), however, values decreased between twelve and eighteen months of storage. Many of the initial-final temperature combinations, especially including +20°F final temperature had higher modulus values than those noted right after freezing (Table 185). Modulus values increased between six and nine months for product frozen to 0°F in 72 and 96 hours, but not for the other two rates (Table 186). Adjusting these data for pre-freezing differences did not alter these differences (Table 187). After nine months of storage, only temperature abused, -10°F initial stored patties yielded higher modulus values to those noted just after freezing (Table 188). In evaluating the initial-final temperature, freezing rate interaction at nine months vs just post-freezing, just one treatment at nine months (-10°F initial, 0°F final temperature) was the same in modulus value to that found right after freezing; all other treatment combinations were higher (Table 189). Data adjustments (pre-freezing) resulted in some comparisons between just post-freezing with nine months to be similar, but most were illogical (Table 190). Between nine and twelve months, modulus values increased only for the nonabused and not the temperature abused patties (Table 191).

Table 182. Interaction effect of initial storage temperature and final storage temperature on Instron modulus values for ground beef patties with soy following twelve months storage^a

Initial storage temperature, °F	Final storage temperature, °F	
	-10	0
-10	39.74 \pm 1.10	37.55 \pm 1.10
0	38.11 \pm 1.10	41.82 \pm 1.10

^aInteraction significant ($P < .05$) by analysis of variance, but not by LSD. Mean \pm S.E. Includes only 0°F in 96 hr freezing rate.

Table 183. Interaction effect of temperature abuse and initial storage temperature on Instron modulus values for ground beef patties with soy following twelve months storage^a

Temperature abuse	Initial storage temperature, °F	
	-10	0
T	37.64 \pm 1.10	41.32 \pm 1.10
N	40.21 \pm 1.10	38.05 \pm 1.10

^aInteraction significant ($P < .05$) by analysis of variance, but not by HSD. Mean \pm S.E.
 T = Temperature abused; N = Not temperature abused. Includes just 0°F in 96 hr rate.

Table 184. Effect of various storage time comparisons on Instron modulus values for ground beef patties with soy

<u>Evaluation time</u>	
<u>Immediately before freezing, 1 day</u>	<u>Immediately after freezing, 1 day</u>
21.79 \pm .55b	27.78 \pm .44a
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
27.78 \pm .98b	33.95 \pm .98a
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
27.78 \pm .56b	37.18 \pm .56a
<u>Immediately following freezing, 1 day</u>	<u>9 months^C</u>
28.04 \pm 2.11b	36.80 \pm 2.11a
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
27.78 \pm .79b	37.36 \pm .79a
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
27.78 \pm .87b	37.81 \pm .87a
<u>12 months</u>	<u>18 months^C</u>
39.13 \pm 1.21a	33.61 \pm 1.21b
<u>Immediately following freezing, 1 day</u>	<u>24 months</u>
27.69 \pm 1.45b	39.12 \pm 1.45a

ab Difference between means on the same line significant ($P < .05$);
Mean \pm S.E.

^CIncludes just 0°F in 96 hr freezing rate.

Table 165. Effect of storage time (immediately following freezing, six months) on Instron modulus values for ground beef patties with soy

		6 months storage			
Immediately following freezing, 1 day	Temperature abuse	Initial Storage temperature, °F =		Final Storage temperature, °F =	
		-10	0	-10	0
27.78 ± .93c	T	30.88 ± .93bc	32.52 ± .93ab	35.15 ± .93ab	33.59 ± .93ab
	N			35.73 ± .93a	
					31.89 ± .93abc
					35.74 ± .93a
					36.11 ± .93a

abc Any mean comparison with the same letters is not different ($P>.05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused.

Table 186. Interaction effect of storage time (six, nine months) and freezing rate on Instron modulus values for ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
6	33.32 \pm .79bcd	33.63 \pm .79bcd	31.96 \pm .79cd	29.98 \pm .79d
9	35.30 \pm .79bc	35.95 \pm .79b	36.89 \pm .79ab	40.60 \pm .79a

abcd Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 187. Interaction effect of storage time (six, nine months) and rate of freezing on Instron modulus values for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	35.79 \pm .79bc	32.69 \pm .79cd	28.78 \pm .79e	31.62 \pm .79de
9	37.77 \pm .79b	35.02 \pm .79bcd	33.71 \pm .79cd	42.24 \pm .79a

abcde Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E.

Table 188. Effect of storage time (immediately following freezing, nine months) on Instron modulus values for ground beef patties with soy

		9 months storage			
Immediately following freezing, 1 day	Temperature abuse	Initial Storage temperature, °F =		Final Storage temperature, °F =	
		-10		-10	
26.04 ± 1.99c	T	41.78 ± 1.99ab	42.29 ± 1.99a	38.04 ± 1.99abc	40.29 ± 1.99a
	N	34.85 ± 1.99abc	30.43 ± 1.99bc	35.12 ± 1.99abc	31.59 ± 1.99a

abc Any mean comparison with the same letters is not different ($P > .05$); Mean ± S.E.; T = Temperature abused; N = Not temperature abused; Includes only 0°F in 96 hr rate.

Table 189. Interaction effect of storage time (immediately after freezing, nine months), initial and final storage temperature and rate of freezing on Instron modulus values for ground beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
Immediately following freezing, 1 day						
9 months	-10	-10	27.49 ± 1.00e	28.28 ± 1.00e	27.31 ± 1.00e	28.04 ± 1.00e
			35.18 ± 1.00cd	36.33 ± 1.00bcd	34.87 ± 1.00cd	41.79 ± 1.00ab
	0	0	33.15 ± 1.00de	35.17 ± 1.00cd	38.82 ± 1.00abcd	42.29 ± 1.00a
			36.84 ± 1.00abcd	36.04 ± 1.00bcd	36.54 ± 1.00abcd	38.04 ± 1.00abc
	0	0	36.04 ± 1.00bcd	36.24 ± 1.00bcd	37.31 ± 1.00abcd	40.29 ± 1.00abc

abcde Any mean comparison with different letters is different ($P < .05$); Mean ± S.E.

Table 190. Interaction effect of storage time (immediately following freezing, nine months), initial storage temperature, final storage temperature and rate of freezing on Instron modulus values for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following, freezing, 1 day					
9 months	-10	-10	29.96 ± 1.00ij	27.35 ± 1.00jk	24.13 ± 1.00k
		0	37.65 ± 1.00defg	35.40 ± 1.00efgh	31.69 ± 1.00hi
			35.62 ± 1.00defgh	34.24 ± 1.00gh	35.64 ± 1.00defgh
	0	-10	39.31 ± 1.00bcde	35.11 ± 1.00fgh	33.36 ± 1.00hi
		0	38.51 ± 1.00cdef	35.31 ± 1.00efgh	34.13 ± 1.00gh
					29.68 ± 1.00ij
					43.42 ± 1.00ab
					43.93 ± 1.00a
					39.68 ± 1.00bcd
					41.93 ± 1.00abc

abcdefghijk Any mean comparison with different letters is different (P<.05). Mean ± S.E.

Table 191. Interaction effect of storage time (nine, twelve months) and temperature abuse on Instron modulus values for ground beef patties with soy

Evaluation time, months	Temperature abuse	
	T	N
9	40.60 \pm 1.06a	33.00 \pm 1.06b
12	39.48 \pm 1.06a	39.13 \pm 1.06a

ab Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.
T = Temperature abused; N = Not temperature abused.

Also, the nonabused patties produced lower Instron modulus values at nine months than was the case for temperature abused patties (Table 191).

The next section of tables depicts results from Instron fail energy tests. Fail energy relates to the work on energy under the curve at 80% of the curve. From the general table (Table 192) much of the differences found for this measurement seem to be associated with formulation (higher for 0°F in 72 hour product) and storage temperature (higher for +20°F product). After all storage intervals and before freezing as well, the 0°F in 72 hour product showed higher fail energy values than the other rates (Table 193). At six months of storage, the use of +20°F final storage temperature produced higher fail energy values (Table 194). Adjusting the freezing rate effects for pre-freezing differences resulted in only one storage time (nine months) being affected by rate. Both the 0°F in 72 and 96 hour product had higher values than 0°F in 24 and 48 hour rates (Table 195). Also, at nine months, it was noted that temperature abuse increased fail energy values (Table 196).

With the exception of the eighteen vs twenty-four month comparison, advances in storage time increased fail energy values (Table 197). At six months, all initial-final temperature comparisons were similar to that found immediately after freezing (Table 198). Between nine and twelve months, there were really no changes in the way freezing rate affected fail energy values - higher for 0°F in 72 hour frozen product (Table 199). Adjusting these data for pre-freezing value differences resulted in no rate effects at nine months and similar values at twelve months between 0°F in 72 and 96 hours (Table 200). Regardless of freezing rate, there were no changes in fail energy values between nine and twelve months. Temperature abuse produced higher values than nonabuse at nine months, but no abuse

Table 192. General table illustrating Instron fall energy values for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.44 ± .47	4.50 ± .69	5.76 ± 1.48	4.29 ± .77
Immediately following freezing, 1 day		4.88 ± 1.11	5.46 ± 1.09	6.72 ± 1.43	4.93 ± .91
6 months	-10T	4.87 ± .92	4.94 ± 1.04	7.14 ± 1.45	4.71 ± 1.26
	OT	5.22 ± .94	4.85 ± 1.01	7.39 ± 1.34	5.03 ± .92
	20T	5.56 ± .74	5.45 ± .78	7.63 ± 1.88	5.66 ± 1.05
	20N	5.87 ± 1.10	5.82 ± .88	7.48 ± 1.68	5.56 ± .81
9 months	-10T	5.13 ± .97	5.03 ± .99	7.58 ± 1.30	5.75 ± 1.15
	-10N				5.15 ± 1.27
	OT	5.24 ± 1.05	5.21 ± .91	7.58 ± 1.36	6.00 ± .99
	ON				4.88 ± 1.16
12 months	-10T	5.42 ± 1.27	5.54 ± .99	7.13 ± 1.41	5.52 ± 1.10
	-10N				5.78 ± 1.05
	OT	5.55 ± .97	5.87 ± 1.09	6.69 ± 1.49	5.41 ± .87
	ON				5.44 ± 1.10
18 months	-10N	5.81 ± 1.05	5.58 ± .86	7.59 ± 1.71	5.39 ± 1.09
	ON	5.58 ± 1.07	5.42 ± .84	7.60 ± 1.30	5.45 ± .78
24 months	-10N	5.58 ± 1.11	4.63 ± .81	6.17 ± 1.35	
	ON	5.47 ± .87	4.86 ± 1.00	6.62 ± 1.49	

^a Mean ± S.D. T = temperature abused, N = not temperature abused.

Table 193. Effect of freezing rate on Instron fail energy values for ground beef patties with soy following various periods of storage

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Just before freezing	4.44 ± .16b	4.50 ± .16b	5.76 ± .16a	4.29 ± .16b
Just after freezing, 1 day	4.88 ± .24b	5.46 ± .24ab	6.72 ± .24a	4.93 ± .24b
6 months	5.38 ± .17b	5.26 ± .17b	7.41 ± .17a	5.24 ± .17b
9 months	5.18 ± .19b	5.12 ± .19b	7.58 ± .19a	5.88 ± .19b
12 months	5.49 ± .14b	5.70 ± .14b	6.91 ± .16a	5.46 ± .14b
18 months	5.69 ± .14b	5.50 ± .14b	7.59 ± .14a	5.42 ± .14b

ab Means on the same line with different letters are different (P<.05).

Mean ± S.E.

Table 194. Effect of final storage temperature on Instron fail energy values for ground beef patties with soy following six months storage

<u>Final storage temperature, °F</u>			
<u>-10T</u>	<u>0T</u>	<u>20T</u>	<u>20N</u>
5.42 \pm .11b	5.62 \pm .11b	6.07 \pm .11a	6.18 \pm .11a

ab Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 195. Effect of freezing rate on Instron fail energy values for ground beef patties with soy following nine months storage -- data adjusted for differences prior to freezing

Freezing rate, hours to 0°F			
24	48	72	96
5.49 \pm .19b	5.37 \pm .19b	6.57 \pm .19a	6.33 \pm .19a

ab Means on the same line with different letters are different (P<.05). Mean \pm S.E.

Table 196. Effect of temperature abuse on Instron fail energy values in ground beef patties with soy following nine months storage

Temperature abuse	
T	N
5.88 \pm .20a	5.01 \pm .20b

ab Difference between means was significant ($P < .05$). Mean \pm S.E. Includes just 0°F in 96 hr. Freezing rate T = temperature abused, N = not temperature abused.

Table 197. Effect of various storage time comparisons on Instron fail energy values for ground beef patties with soy

<u>Evaluation time</u>	
<u>Immediately before freezing</u>	<u>Immediately after freezing, 1 day</u>
4.75 ± .11b	5.50 ± .09a
<u>6 months</u>	<u>9 months</u>
5.52 ± .09b	5.94 ± .09a
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
5.50 ± .20b	5.94 ± .20a
<u>Immediately following freezing, 1 day</u>	<u>12 months^c</u>
4.93 ± .25b	5.54 ± .25a
<u>Immediately following freezing, 1 day</u>	<u>12 months^d</u>
5.50 ± .17b	5.88 ± .17a
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
5.50 ± .16b	6.05 ± .16a
<u>18 months</u>	<u>24 months</u>
6.26 ± .10a	5.56 ± .12b

ab Differences between means on the same line significant ($P < .05$).
Mean ± S.E.

^c Includes only 0°F in 96 hr freezing rate.

^d Includes just temperature-abused product.

Table 198. Effect of storage time (immediately following freezing, six months)
on Instron fail energy values for ground beef patties with soy

		6 months storage			
		Initial storage temperature, °F =		0	
Immediately following freezing, 1 day	Temperature abuse	Final storage temperature, °F =			
		-10	20	-10	20
5.50 ± .16ab	T	5.38 ± .16b	5.56 ± .16ab	5.45 ± .16ab	5.68 ± .16ab
	N		6.03 ± .16ab		6.12 ± .16a
			6.18 ± .16a		6.19 ± .16a

ab Any mean comparison with different letters is different ($P < .05$). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 199. Interaction effect of storage time (nine, twelve months) and rate of freezing on Instron fail energy values for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0° F			
	24	48	72	96
9	5.18 \pm .18b	5.12 \pm .18b	7.58 \pm .18a	5.88 \pm .18b
12	5.49 \pm .18b	5.70 \pm .18b	6.85 \pm .22a	5.46 \pm .18b

ab Any mean comparison with the same letters is not different ($P > .05$).

Mean \pm S.E.

Table 200. Interaction effect of storage time (nine, twelve months) and rate of freezing on Instron fail energy values for ground beef patties with soy -- data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	5.49 \pm .18bc	5.37 \pm .18c	6.57 \pm .18a	6.33 \pm .18ab
12	5.79 \pm .18abc	5.95 \pm .18abc	5.84 \pm .22abc	5.92 \pm .18abc

abc Any means comparison with different letters is different
($P < .05$). Mean \pm S.E.

differences were noted at twelve months (Table 201). Following eighteen months of storage, patties stored initially at 0°F and finally at -10°F had higher fat energy values than those observed after freezing (Table 202).

The next general section of the report covers weight losses incurred at various stages from freezing through cooking. Compared to roasts and bulk ground beef, weight changes were not affected as much by project variables. This can be easily observed in the "total project" loss or loss from before freezing until after cooking illustrated in Table 203. The only time freezing rate affected the weight loss from before freezing until after cooking was following twenty-four months of storage; and then there were only indications (nonsignificant, $P>.05$, by HSD) of lower losses for the 0°F in 24 hour rate (Table 204).

Storage for six, nine and eighteen months yielded more weight loss from before freezing until after cooking compared to just after freezing. However, nine months storage produced more total project loss than twelve months storage (Table 205). After six months storage, patties initially stored at 0°F and then at +20°F had more total weight loss than that recorded just after freezing (Table 206). Following nine months of storage, patties stored initially and finally at 0°F had more total project loss than just after freezing. After eighteen months of storage, patties stored initially at -10°F and finally at 0°F had more total project loss than that noted post-freezing (Table 207).

General information relating to the percent weight loss of ground beef patties from before freezing until after storage is provided in Table 208. In some cases, longer storage meant more weight loss. Following six months of storage, patties originally frozen to 0°F in 24 hours had less weight

Table 201. Interaction effect of storage time (nine, twelve months) and temperature abuse on Instron fail energy values for ground beef patties with soy

Evaluation time, months	Temperature abuse	
	T	N
9	5.88 \pm .15a	5.01 \pm .15b
12	5.46 \pm .15ab	5.61 \pm .15ab

ab Any mean comparison with the same letter is not different ($P > .05$).

Mean \pm S.E. T = temperature abused, N = not temperature abused. Includes just 0°F in 96 hr rate.

Table 202. Effect of storage time (just after freezing, eighteen months) on Instron fall energy values for ground beef patties with soy

Immediately following freezing, 1 day	18 months storage		
	Initial storage temperature, °F =		
	-10		0
5.50 ± .14b	Final storage temperature, °F =		
	-10	0	
	6.04 ± .14ab	6.06 ± .14ab	6.14 ± .14a
			5.96 ± .14ab

ab Means on the same line with different letters are different ($P < .05$). Mean ± S.E. Includes just nontemperature abused product.

Table 203. General table illustrating the percent change in weight of ground beef patties with soy from just before freezing until after cooking throughout storage and according to final storage temperature and rate of freezing -
- no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day					
6 months	-10T	-31.20 + .07	-31.48 + 3.62	-33.46 + 1.37	-33.31 + .88
	0T	-33.08 + 1.34	-35.40 + 2.04	-33.84 + 1.78	-34.69 + .96
	20T	-33.63 + 1.02	-35.07 + 1.29	-33.62 + 2.37	-34.18 + 1.62
	20N	-34.64 + .63	-35.94 + .3	-34.19 + 2.49	-33.60 + 1.83
9 months	-10T	-32.50 + 2.18	-35.92 + 1.32	-35.37 + 1.06	-34.77 + 1.14
	-10N	-32.42 + 1.1	-33.69 + 2.09	-34.1 + 1.82	-35.11 + .60
	0T	-32.49 + .27	-35.54 + 1.2	-34.34 + 2.28	-34.57 + 1.78
	0N	--	--	--	-33.46 + .35
12 months	-10T	-32.49 + 1.21	-33.62 + 1.87	-32.17 + 1.26	-33.59 + 1.05
	-10N	--	--	--	-34.29 + .70
	0T	-32.46 + .89	-32.69 + 1.42	-33.58 + .21	-33.45 + 1.21
	0N	--	--	--	-33.28 + 2.45
18 months	-10N	-31.72 + .82	-33.49 + 1.03	-33.67 + .46	-33.44 + .43
	0N	-33.14 + .27	-34.27 + .44	-33.08 + 1.31	-34.16 + 1.26
24 months	-10N	-32.23 + .5	-33.25 + .63	-32.9 + 1.52	--
	0N	-32.17 + .54	-33.58 + .41	-33.27 + .53	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 204. Effect of freezing rate on percent change in weight of ground beef patties with soy from before freezing until after cooking, for patties stored twenty-four months^a

<u>Freezing rate, hours to 0°F</u>		
<u>24</u>	<u>48</u>	<u>72</u>
-32.2 ± .28	-33.42 ± .29	-33.69 ± .40

^aDifferences significant ($P < .05$) by analyses of variance, but not by HSD.

Table 205. Effects of various storage time comparisons on percent change in weight of ground beef patties with soy from just before freezing until after cooking

Evaluation times	
Immediately following freezing, 1 day	6 months
-32.36 \pm .48b	-34.19 \pm .48a
Immediately following freezing, 1 day	9 months
-32.36 \pm .54b	-34.05 \pm .54a
Immediately following freezing, 1 day	18 months
-32.36 \pm .36b	-33.43 \pm .36a
9 months	12 months
-34.05 \pm .43a	-32.88 \pm .43b

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

Table 206. Effect of various storage times (immediately following freezing, six months) on percent change in weight of ground beef patties with soy from just before freezing until after cooking

	6 months storage					
. Initial Storage temperature, °F =	-10				0	
Immediately following freezing, 1 day						
	-10T	OT	20T	.20N	-10T	20T
	-34.05 ± .46ab	-34.11 + .46ab	-34.38 + .46ab	-34.31 ± .46ab	-34.45 + .46ab	34.13 + .46ab
	-32.36 ± .46bb				-34.81 ± .46a	-34.96 ± .

ab Means on the same line with the same letters are not different ($P>.05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused.

Table 207. Effect of various storage time comparisons on percent change in weight of ground beef patties with soy from before freezing until after cooking

9 months storage			
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10	U
	Final Storage temperature, °F =	-10	U
-32.36 ± .48b	-34.11 ± .55ab	-33.73 ± .48ab	-33.61 ± .48ab -34.73 ± .46a
18 months storage			
-32.36 ± .33b	-32.9 ± .33ab	-34.18 ± .33a	-33.26 ± .33ab -33.4 ± .33ab

ab Means on the same line within a storage time with the same letters are not different ($P > .05$);
Mean ± S.E.

Table 208. General table illustrating the percent change in weight of ground beef patties with soy from just before freezing until after storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F				
		24	48	72	96	
6 months	-10T	-1.12 + .52	-1.18 + .27	-1.47 + .19	-1.38 + .49	
	0T	- .98 + .32	-1.03 + .18	-1.26 + .41	-1.28 + .33	
	20T	- .98 + .15	-1.40 + .54	-1.56 + .56	-1.26 + .46	
	20N	- .65 + .18	-1.37 + .29	-1.07 + .32	-1.03 + .11	
9 months	-10T	-1.04 + .49	-1.03 + .22	-1.88 + 1.11	-1.2 + .26	
	-10N	--	--	--	-1.75 + .65	
	0T	-1.00 + .37	-1.25 + .45	-1.78 + 1.21	-1.07 + .36	
	0N	--	--	--	-1.34 + .51	
12 months	-10T	- .98 + .19	-1.22 + .46	-1.10 + .52	-1.63 + 1.02	
	-10N	--	--	--	-1.64 + .43	
	0T	- .78 + .13	-1.38 + .37	-2.04 + .79	-1.73 + .36	
	0N	--	--	--	-1.5 + .25	
18 months	-10N	-1.02 + .48	- .91 + .40	-2.11 + 1.52	-2.13 + .79	
	0N	-1.93 + 1.24	-2.11 + .78	-2.77 + .99	-2.25 + .30	
24 months	-10N	-2.03 + .43	-1.69 + .73	-1.54 + .44	--	
	0N	-2.19 + .45	-1.87 + .60	-1.46 + .69	--	

^aMean + S.D.; T = Temperature abused; N = Not temperature abused.

loss than those frozen to 0°F in 72 hours (Table 209). At twelve months storage, patties initially stored at -10°F had less weight loss than those stored at 0°F (Table 210). There were indications that, that form of weight loss increased between eighteen and twenty-four months of storage if the freezing rate was 0°F in 24 hours, while the opposite was the situation if the freezing rate was 0°F in 72 hours (Table 211). At eighteen months of storage, patties finally stored at -10°F had lower weight losses from before freezing until after storage than patties finally stored at 0°F; no differences were found due to these two temperatures at twenty-four months of storage (Table 212).

Data relating to weight reduction just due to freezing are shown in Table 213. Values were unaffected ($P>.05$) by freezing rate.

Losses occurring just during frozen storage are provided in general format in Table 214. Values vary but do increase with advancements in storage time. At six months of storage, patties originally frozen to 0°F in 24 hours had lower storage losses than patties originally frozen to 0°F in 72 hours (Table 215). No temperature abuse substantially increased storage loss at nine months for patties initially stored at 0°F; these differences were not detected for patties initially stored at -10°F (Table 216). At twelve months, patties stored at -10°F initial temperature had less change in weight during storage than patties stored at 0°F (Table 217). Patties originally frozen to 0°F in 24 hours had less weight loss during storage than 0°F in 72 hour product after eighteen months, while no differences were detected between these rates after twenty-four months of storage (Table 218). Also, at eighteen months, but not at twenty-four months, more weight was lost during frozen storage when patties were finally stored at -10°F vs 0°F (Table 219).

Table 209. Effect of freezing rate on percent change in weight of ground beef patties with soy from just before freezing until after six months storage

Freezing rate, hours to 0°F			
24	48	72	96
- .93 \pm .098b	-1.24 \pm .098ab	-1.34 \pm .098a	-1.24 \pm .098ab

ab Any mean on the same line with the same letter is not different ($P > .05$); Mean \pm S.E.

Table 210. Effect of initial storage temperature on percent change in ground beef patties with soy from just before freezing until after twelve months storage^a

Initial Storage Temperature, °F	
-10	0
-1.43 ± .12	-1.82 ± .12

^aDifference between means significant ($P < .05$) by analysis of variance, but not HSD.

Table 211. Interaction effect of storage time (eighteen, twenty-four months) and rate of freezing on percent change in weight of ground beef patties with soy from before freezing until after storage^a

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	-1.47 ± .21	-1.51 ± .21	-2.44 ± .21
24	-2.11 ± .21	-1.78 ± .21	-1.72 ± .30

^aInteraction significant ($P < .05$) by analyses of variance, but not BSP. Mean ± S.E.

Table 212. Interaction effect of storage time (eighteen, twenty-four months) and final storage temperature on percent change in weight of ground beef patties with soy from just before freezing until after storage

Evaluation time, months	Final storage temperature, °F	
	-10	0
18	-1.35 \pm .17b	-2.27 \pm .17a
24	-1.83 \pm .2ab	-1.91 \pm .17ab

ab Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.

Table 213. General table illustrating the percent change in weight from just before until just after freezing for ground beef patties with soy through storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day					
6 months	-10T	-.68 ± .32	-.76 ± .16	-.92 ± .14	-.75 ± .25
	OT	-.74 ± .20	-.61 ± .15	-.76 ± .39	-.88 ± .24
	20T	-.67 ± .13	-.69 ± .12	-.83 ± .33	-.66 ± .25
	20N	-.71 ± .05	-.83 ± .17	-.82 ± .38	-.73 ± .34
9 months	-10T	-.68 ± .15	-.81 ± .12	-.75 ± .39	-.84 ± .14
	-10T	-.56 ± .20	-.73 ± .10	-.55 ± .25	-.79 ± .12
	-10N	--	--	--	-.97 ± .20
	OT	-.53 ± .16	-.82 ± .36	-.66 ± .18	-.89 ± .41
12 months	ON	--	--	--	-.72 ± .11
	-10T	-.67 ± .17	-.73 ± .12	-.34 ± .05	-.76 ± .22
	-10N	--	--	--	-.77 ± .04
	OT	-.62 ± .09	-.77 ± .16	-.83 ± .22	-.87 ± .16
18 months	ON	--	--	--	-.89 ± .06
	-10N	-.69 ± .14	-.60 ± .11	-.55 ± .12	-.97 ± .43
	ON	-.69 ± .22	-.71 ± .12	-.56 ± .14	-1.02 ± .36
24 months	-10N	-.59 ± .19	-.76 ± .22	-.63 ± .11	--
	ON	-.77 ± .18	-.75 ± .18	-.61 ± .06	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 214. General table illustrating the percent change in weight from just after freezing until after storage for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F				
		24	48	72	96	
6 months	-10T	- .39 + .59	- .57 + .16	- .72 + .34	- .51 + .33	
	OT	- .32 + .29	- .34 + .07	- .44 + .16	- .63 + .44	
	20T	- .27 + .19	- .58 + .51	- .74 + .21	- .49 + .24	
	20N	- .026 + .17	- .57 + .29	- .31 + .21	- .19 + .08	
9 months	-10T	- .49 + .39	- .3 + .17	- 1.34 + .96	- .42 + .17	
	-10N	--	--	--	- .79 + .47	
	OT	- .48 + .37	- .43 + .18	- 1.13 + 1.11	- .19 + .13	
	ON	--	--	--	- .62 + .50	
12 months	-10T	- .31 + .12	- .055 + .32	- .76 + .57	- .88 + .72	
	-10N	--	--	--	- .88 + .40	
	OT	- .15 + .09	- .62 + .32	- 1.22 + .88	- .87 + .42	
	ON	--	--	--	- .61 + .19	
18 months	-10N	- .33 + .52	- .31 + .36	- 1.57 + 1.51	- 1.17 + .80	
	ON	- 1.24 + 1.17	- 1.41 + .84	- 2.22 + 1.12	- 1.24 + .22	
24 months	-10N	- 1.44 + .58	- .94 + .65	- .91 + .35	--	
	ON	- 1.43 + .42	- 1.12 + .64	- .86 + .74	--	

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 215. Effect of freezing rate on percent change in weight of ground beef patties with soy from just after freezing until six months of storage

Freezing rate, hours to 0°F			
24	48	72	96
-0.24 ± 0.08b	-0.52 ± 0.08ab	-0.55 ± 0.08a	-0.45 ± 0.08ab

ab Means on the same line with the same letter are not different ($P > .05$); Mean ± S.E.

Table 216. Interaction effect of temperature abuse and initial storage temperature on percent change in weight of ground beef patties with soy during nine months frozen storage

Temperature abuse	Initial storage temperature, °F	
	-10	0
T	$-.42 \pm .12b$	$-.19 \pm .12b$
N	$-.33 \pm .12b$	$-1.08 \pm .12a$

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E;
 T = Temperature abused; N = Not temperature abused.

Table 217. Effect of initial storage temperature on percent change in weight of ground beef patties with soy during twelve months frozen storage

Initial storage temperature, °F	
-10	0
-0.61 ± .10b	-1.01 ± .10a

ab Difference between means significant ($P < .05$);
Mean ± S.E.

Table 218 Interaction effect of storage time (eighteen, twenty-four months) and freezing rate on percent change in weight of ground beef patties with soy during frozen storage

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	.78 \pm .21b	.86 \pm .21ab	1.89 \pm .21a
24	1.44 \pm .21ab	1.03 \pm .21ab	1.11 \pm .29ab

ab Any mean comparisons with the same letter are not different ($P > .05$); Mean \pm S.E.; Includes only non-temperature abused product.

Table 219. Interaction effect of storage time (eighteen, twenty-four months) and final storage temperature on percent change in weight of ground beef patties with soy during frozen storage

Evaluation time, months	Final storage temperature, 0°F	
	-10	0
18	- .74 \pm .17b	-1.63 \pm .17a
24	-1.16 \pm .19ab	-1.23 \pm .19ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.; Includes only non-temperature abused product.

The next section of the report deals with cooking properties. Just the process of freezing produced reductions in cooking loss (Table 220). This is in agreement with the increased weight loss for patties prior to cooking as a result of freezing. After nine months of storage, temperature abuse generated less cooking loss than no abuse (Table 221). Patties frozen to 0°F in 24 hours and evaluated at twenty-four months of storage had less cooking loss than patties originally frozen to 0°F in 48 and 72 hours (Table 222).

Freezing produced an approximately 9% reduction in cooking loss (Table 223). Six and nine months of storage had more cooking loss than that found right after freezing. Also, twelve months of storage had less cooking loss than nine months of storage. There were indications that temperature abuse increased cooking loss at nine months but not twelve months of storage (Table 224).

Changes in patty thickness as a result of cooking were highly variable respective to the variables under study (Table 225). Considerable increases in thickness occurred for the patties that were never frozen. This occurred again following twelve months of storage for patties from the 0°F in 24 and 48 hour freezing rates. Differences were noted at many of the storage periods for freezing rate, but followed no particular trend (Table 226). After nine months of storage, patties that had been stored under a final temperature of -10°F underwent less reduction in thickness during cooking than patties stored at 0°F (Table 227). Temperature abuse produced much more reduction in thickness than nonabuse. After twelve months of storage (Table 228). For some unexplainable reason, patties from the 0°F in 24 and 48 hour rates underwent a sizable increase in thickness,

Table 220. General table illustrating the percent cooking loss for ground beef patties with soy throughout storage and according to final storage temperature, and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		40.89 ± .075	41.56 ± 1.33	43.26 ± .52	40.97 ± .81
Immediately following freezing, 1 day		31.35 ± .30	32.65 ± 1.72	33.67 ± 1.27	33.60 ± .87
6 months	-10T	33.08 ± 1.33	35.10 ± 2.16	33.72 ± 1.84	34.47 ± 1.16
	0T	33.53 ± 1.21	34.86 ± 1.29	33.55 ± 2.54	34.16 ± 1.52
	20T	34.64 ± .78	35.52 ± .36	34.03 ± 2.35	33.52 ± 1.91
	20N	32.66 ± 2.10	35.58 ± 1.41	35.47 ± 1.17	34.92 ± 1.06
9 months	-10T	32.19 ± .84	33.44 ± 2.31	33.9 ± 1.97	35.03 ± .73
	-10N	--	--	--	32.83 ± .76
	0T	32.35 ± .48	35.22 ± 1.38	34.36 ± 2.27	34.59 ± 1.82
	0N	--	--	--	33.17 ± .84
12 months	-10T	32.27 ± 1.33	31.39 ± 1.05	32.10 ± .94	33.15 ± .82
	-10N	--	--	--	34.05 ± .79
	0T	32.50 ± .95	32.24 ± 1.60	32.99 ± .43	32.98 ± 1.12
	0N	--	--	--	33.32 ± 1.80
18 months	-10N	31.50 ± 1.04	33.23 ± .81	32.89 ± 1.20	32.69 ± .88
	0N	32.28 ± .55	33.11 ± .70	31.73 ± 1.63	32.82 ± .48
24 months	-10N	31.11 ± .57	32.41 ± .90	32.33 ± 1.22	--
	0N	31.05 ± .34	32.34 ± .66	32.77 ± .56	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 221. Effect of temperature abuse on percent cooking loss in ground beef patties with soy following nine months storage

T	N
34.81 \pm .42a	33.0 \pm .42b

ab Difference between means significant ($P < .05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused; Includes only 0°F in 96 hr frozen product.

Table 222. Effect of freezing rate on percent cooking loss in ground beef patties with soy following twenty-four months storage

<u>Freezing rate, hours to 0°F</u>		
<u>24</u>	<u>40</u>	<u>72</u>
31.09 ± .25b	32.38 ± .25a	32.55 ± .25a

^aMeans on the same line with different letters are different ($P < .05$); ^bMean ± S.E.

Table 223. Effects of various storage time comparisons on percent cooking loss in ground beef patties with soy

Evaluation times	
Before freezing	Immediately following freezing, 1 day
41.67 \pm .41a	32.82 \pm .32b
Immediately following freezing, 1 day	6 months
32.82 \pm .48b	34.06 \pm .48a
Immediately following freezing, 1 day	9 months
32.82 \pm .49b	33.91 \pm .49a
9 months	12 months
33.91 \pm .35a	32.88 \pm .35b

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

Table 224. Interaction effect of storage time (nine, twelve months) and temperature abuse on percent cooking loss in ground beef patties with soy^a

Evaluation time, months	Temperature abuse	
	T	N
9	34.81 \pm .51	33.0 \pm .51
12	33.06 \pm .51	33.68 \pm .51

^aInteraction effect significant ($P < .05$) by analysis of variance, but not by HSD.

Table 225. General table illustrating percent change in patty thickness during cooking for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		27.42 ± 13.92	13.58 ± 8.92	21.74 ± 12.80	19.09 ± 12.56
Immediately following freezing, 1 day		5.99 ± 7.36	-7.36 ± 8.05	0.070 ± 8.22	-5.57 ± 8.33
6 months	-10T	-7.01 ± 7.83	-12.59 ± 7.15	-4.09 ± 6.72	-5.43 ± 9.23
	0T	-3.91 ± 6.24	-13.08 ± 7.21	-6.14 ± 5.43	-7.14 ± 7.22
	20T	-3.69 ± 7.08	-9.79 ± 5.26	-5.11 ± 8.62	-8.40 ± 6.29
	20N	-5.65 ± 6.11	-10.23 ± 8.08	-4.53 ± 7.25	-7.29 ± 8.59
9 months	-10T	2.04 ± 6.65	-5.23 ± 6.61	-5.95 ± 5.52	-0.22 ± 6.53
	-10N				-4.35 ± 5.31
	0T	1.29 ± 6.21	-5.85 ± 7.72	-6.16 ± 6.37	-1.19 ± 6.13
	0N				0.027 ± 7.50
12 months	-10T	25.27 ± 6.76	21.15 ± 8.14	-10.01 ± 8.33	-4.68 ± 6.05
	-10N				1.48 ± 6.76
	0T	29.33 ± 7.39	22.43 ± 7.02	.42 ± 7.56	-7.79 ± 7.06
	0N				-1.08 ± 6.54
18 months	-10N	1.79 ± 6.89	-5.44 ± 7.33	-5.70 ± 8.90	-9.71 ± 7.44
	0N	.73 ± 7.42	-4.15 ± 6.76	-7.87 ± 5.82	-11.00 ± 6.27
24 months	-10N	-8.75 ± 6.70	-6.79 ± 8.53	-3.77 ± 7.75	
	0N	-9.90 ± 7.15	-5.95 ± 8.90	-1.73 ± 5.72	

^a Mean ± S.D. T = temperature abused, N = not temperature abused.

Table 226. Effect of freezing rate on percent change in patty thickness during cooking for ground beef patties with soy at various storage periods

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing	27.42 ± 2.20b	13.58 ± 2.20a	21.74 ± 2.20ab	19.09 ± 2.20ab
6 months	-5.07 ± .96b	-11.42 ± .96a	-4.97 ± .96b	-7.06 ± .96b
9 months	1.66 ± .95b	-5.54 ± .95a	-6.05 ± .95a	-0.71 ± .95b
18 months	1.26 ± 1.11c	-4.79 ± 1.11b	-6.79 ± 1.11ab	-10.36 ± 1.11a
24 months	-9.33 ± .78a	-6.37 ± .78a	-2.75 ± 1.10b	

abc Means on the same line with different letters are different ($P < .05$). Mean ± S.E.

Table 227. Effect of final storage temperature on percent change in patty thickness during cooking for ground beef patties with soy following nine months storage

Final storage temperature, °F	
-10	0
-6.08 \pm 1.17b	-11.03 \pm 1.35a

ab Difference between means is significant ($P < .05$); Mean \pm S.E.

Table 228. Effect of temperature abuse on percent change in patty thickness during cooking for ground beef patties with soy following twelve month storage

Temperature abuse	
T	N
-6.24 \pm 1.08a	.20 \pm 1.08b

ab Difference between means significant ($P < .05$). Mean \pm S.E. Includes only 0°F in 96 hr product. T = temperature abused, N = not temperature abused.

while the other two rates produced a decrease in patty thickness during cooking (Table 229, 230).

With the exception of twelve months, storage time comparisons generally showed in relation to just post-freezing, a greater reduction in patty thickness (Table 231). However, following six months storage, only patties initially stored at 0°F and finally at +20°F had more reduction during cooking than that noted just post-freezing (Table 232). Between six and nine months, less reduction in thickness during cooking was found for the 0°F in 24 hour rate, while the opposite was true for the 0°F in 48 hour rate (Table 233). Substantial increases in patty thickness from cooking occurred between nine and twelve months for the 0°F in 24 and 48 hour rate (Table 234). Between nine and twelve months, temperature abused product underwent more shrink during cooking. Temperature abused patties also had more shrink than nonabused patties at twelve months (Table 235). The large swelling in thickness of 0°F in 24 and 48 hour frozen patties was noted strictly at twelve months (Table 236). Patties receiving no temperature abuse and finally stored at -10°F underwent slight swelling with cooking after twelve months (Table 237). Between eighteen and twenty-four months of storage, more reduction in thickness was found for patties subjected to 0°F in 24 hour freezing while the opposite was observed for 0°F in 72 hour freezing (Table 238). At twenty-four months of storage, all rates except 0°F in 48 hours had more shrink in thickness during cooking compared to values recorded just after freezing (Table 239).

General data reflecting percent change in patty diameter during cooking is illustrated in Table 240. There did not appear to be any major effects of study variables on patty diameter properties. At six months of

Table 229. Interaction effect of initial storage temperature and freezing rate on percent change in patty thickness during cooking for ground beef patties with soy following twelve months storage

Initial storage temperature, °F	Freezing rate, hours to 0°F		
	24	48	72
-10	28.52 + 1.12c	21.71 + 1.12c	.10 + 1.49b
0	26.08 + 1.12c	21.86 + 1.12c	-9.70 + 1.49a
			-7.67 + 1.12a
			-4.81 + 1.12ab

abc Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 230. Interaction effect of final storage temperature and rate of freezing on percent change in patty thickness during cooking for ground beef patties with soy following twelve months storage

Final storage temperature, °F	Freezing rate, hours to 0°F		
	24	48	72
-10	25.26 + 1.12cd	21.15 + 1.12c	-10.01 + 1.49a
0	29.33 + 1.12d	22.43 + 1.12c	.42 + 1.49b
			-4.68 + 1.12ab
			-7.79 + 1.12a

abcd Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 231. Effect of various storage time comparisons on percent change in patty thickness during cooking for ground beef patties with soy

<u>Evaluation time</u>	
<u>Immediately before freezing</u>	<u>Immediately following freezing, 1 day</u>
20.46 + 1.02b	-1.72 + .81a
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
-1.72 + 1.37b	-7.13 + 1.37a
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
-1.72 + 1.08a	10.42 + 1.08b
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
-1.72 + 1.25b	-5.17 + 1.25a
<u>12 months^c</u>	<u>18 months^c</u>
.20 + 1.46b	-10.36 + 1.46a
<u>Immediately following freezing, 1 day^d</u>	<u>24 months^d</u>
-.43 + 1.00b	-6.70 + 1.00a

ab Differences between means on same line significant ($P < .05$). Mean + S.E.

c Includes just 0°F in 96 hr rate.

d Includes just nonabused product.

Table 232. Effect of storage time (immediately following freezing, six months) on percent change in patty thickness during cooking for ground beef patties with soy

		6 months storage					
Immediately following freezing, 1 day	abuse	Initial storage temperature, °F					
		-10	0	-10	0		
		Temperature		Final storage temperature, °F =			
		-10	0	20	20		
-1.72 ± 1.30b	T	-7.18 ± 1.30ab	-7.40 ± 1.30ab	-6.88 ± 1.30ab	-7.38 ± 1.30ab	-7.73 ± 1.30ab	-6.62 ± 1.30
	N			-5.61 ± 1.30ab			-8.24 ± 1.30

ab Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 233. Interaction effect of storage time (six, nine months) and rate of freezing on percent change in patty thickness during cooking for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
6	-5.46 + 1.16b	-12.84 + 1.16a	-5.11 + 1.16b
9	1.66 + 1.16c	-5.54 + 1.16b	-6.05 + 1.16b

abc Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 234. Interaction effect of storage time (nine, twelve months) and rate of freezing on percent change in patty thickness during cooking for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	1.66 ± .81b	-5.54 ± .81a	-6.05 ± .81a	-.71 ± .81b
12	27.30 ± .81d	21.79 ± .81c	-5.22 ± 1.14a	-6.24 ± .81a

abcd Any mean comparison with different letters is different ($P < .05$).
Mean ± S.E.

Table 235. Interaction effect of storage time (nine, twelve months) and temperature abuse on percent change in patty thickness during cooking for ground beef patties with soy

Evaluation time, months	Temperature Abuse	
	T	N
9	- .71 \pm .82b	-2.45 \pm 1.00ab
12	-6.24 \pm .82a	.20 \pm .82b

ab Any mean comparison with the same letter is not different ($P > .05$). Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 236. Interaction effect of storage time (immediately following freezing, twelve months), initial storage temperature, final storage temperature and rate of freezing on percent change in patty thickness during cooking for ground bee patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10	-10	5.99 + 1.92d	-7.36 + 1.92abc	.07 + 1.92bcd	-5.57 + 1.92ab
			27.65 + 1.92e	20.49 + 1.92e	-5.76 + 1.92abcd	-5.75 + 1.92ab
	0	0	29.39 + 1.92e	22.93 + 1.92e	4.35 + 2.94cd	-9.59 + 1.92ab
			22.88 + 1.92e	21.80 + 1.92e	-12.64 + 2.94a	-3.61 + 1.92ab
			29.28 + 1.92e	21.92 + 1.92e	-5.13 + 1.92abcd	-6.00 + 1.92ab

abcde Any mean comparison with different letters is different ($P < .05$). Mean + S.E.



Table 237. Effect of storage time (immediately after freezing, twelve months) on percent change in patty thickness during cooking for ground beef patties with soy

Evaluation time			
12 months storage			
Temperature abuse			
Immediately following freezing, 1 day	T		N
	Final storage temperature, °F =		
	-10	0	-10
-5.56 + 2.16ab	-4.68 + 1.53ab	-7.79 + 1.53a	1.48 + 1.53b
			-1.08 + 1.53ab

ab Means on the same line with the same letters are the same ($P > .05$). Mean + S.E.

T = temperature abused, N = not temperature abused. Includes 0° in 96 hr rate only.

1060Q, p. 20

Table 238. Interaction of storage time (eighteen, twenty-four months) and freezing rate on percent change in patty thickness during cooking for ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	1.26 \pm .58c	-4.79 \pm .58b	-6.79 \pm .58ab
24	-9.33 \pm .58a	-6.37 \pm .58b	-1.53 \pm .83c

abc Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 239. Interaction effect of storage time (immediately following freezing, twenty-four months), initial storage temperature, final storage temperature and rate of freezing on percent change of patty thickness during cooking for ground beef patties with soy

Evaluation time	Initial storage temperature, 0°F	Final storage temperature, 0°F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day			5.99 + 1.54c	-7.36 + 1.54ab	.07 + 1.54bc
24 months	-10	-10	-7.73 + 1.54ab	-7.52 + 1.54ab	-4.42 + 2.34ab
		0	-8.71 + 1.54ab	-5.12 + 1.54ab	-3.08 + 1.54abc
	0	-10	-9.77 + 1.54ab	-6.05 + 1.54ab	-4.08 + 1.54ab
		0	-11.10 + 1.54a	-6.78 + 1.54ab	-1.36 + 2.34abc

ab Any mean comparison with the same letters is not different ($P>.05$). Mean ± S.E.

Table 240. General table illustrating the percent change in patty diameter during cooking for ground beef patties with soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^d

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		-16.83 ± 2.21	-16.55 ± 1.38	-14.43 ± 3.24	-14.35 ± 4.27
Immediately following freezing, 1 day		-15.63 ± 2.10	-16.36 ± 2.79	-16.97 ± 3.03	-18.21 ± 2.20
6 months	-10	-16.41 ± 2.20	-16.61 ± 2.26	-17.98 ± 1.72	-16.72 ± 2.65
	0	-16.38 ± 2.41	-16.45 ± 1.73	-17.87 ± 2.08	-16.43 ± 1.57
	20T	-17.20 ± 1.66	-16.86 ± 1.76	-18.06 ± 1.70	-18.14 ± 2.00
	20N	-17.14 ± 1.21	-17.94 ± 1.50	-19.09 ± 1.61	-17.56 ± 2.09
9 months	-10T	-15.50 ± 1.65	-14.86 ± 2.20	-18.22 ± 3.09	-18.35 ± 2.00
	-10N	--	--	--	-15.28 ± 2.07
	0T	-15.46 ± 2.17	-14.44 ± 1.68	-19.95 ± 2.34	-17.95 ± 2.38
	0N	--	--	--	-15.64 ± 1.61
12 months	-10T	-16.60 ± 1.51	-15.63 ± 2.36	-16.61 ± 2.04	-17.09 ± 2.08
	-10N	--	--	--	-16.75 ± 1.58
	0T	-17.72 ± 2.06	-15.96 ± 2.30	-17.19 ± 1.51	-17.94 ± 1.86
	0N	--	--	--	-17.39 ± 1.99
15 months	-10N	-16.84 ± 2.87	-15.27 ± 2.32	-16.10 ± 2.82	-15.02 ± 2.41
	0N	-17.83 ± 1.79	-15.44 ± 2.35	-17.35 ± 2.58	-15.68 ± 2.14
18 months	-10N	-16.75 ± 2.11	-15.52 ± 2.33	-15.24 ± 2.53	--
	0N	-16.25 ± 2.69	-15.53 ± 2.19	-18.21 ± 2.00	--

Mean ± S.D.; T = Temperature abused; N = Not temperature abused.

storage, temperature abused patties stored at -10° and 0°F final temperature had less reduction in patty diameter than patties not receiving abuse and stored at $+20^{\circ}\text{F}$ (Table 241). Following nine months of storage, patties frozen to either 0°F in 24 or 48 hours had less reduction in patty diameter than patties frozen to 0°F in 72 and 96 hours (Table 242). At eighteen months, patties frozen to 0°F in either 48 or 96 hours had less diameter shrinkage during cooking than patties frozen to 0°F in 24 hours. Nonabused patties underwent less diameter shrinkage than temperature abused patties following nine months of storage (Table 243). Also, at nine months, for patties finally stored at 0°F , those initially stored at 0°F had more diameter reduction in cooking than patties initially stored at -10°F (Table 244).

Only one freezing rate (0°F in 96 hours) underwent any difference in percent change in patty diameter simply as a matter of freezing; more after freezing (Table 245). At six months of storage, all temperature combinations produced similar reductions in patty diameter to that found right after freezing (Table 246). Between six and nine months of storage, the amount of diameter shrinkage increased only for 0°F in 72 hour frozen product (Table 247). Between nine and twelve months of storage, patty diameter shrinkage increased for 0°F in 24 and 48 hour rates and decreased for 0°F in 72 hour rates (Table 248). Temperature abuse produced an increase in diameter shrinkage during cooking at nine months, but not at twelve months (Table 249). Very few differences in patty diameter shrinkage were observed after twelve months of storage (Table 250). More patty diameter reduction was noted at eighteen months vs twelve months (Table 251).

Table 241. Effect of final storage temperature on percent change in patty diameter during cooking for ground beef patties with soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
-16.93 \pm .25b	-16.78 \pm .25b	-17.56 \pm .25ab	-17.93 \pm .25a

ab Means on the same line with different letters are different ($P < .05$); T = Temperature abused; N = Not temperature abused.

Table 242. Effect of freezing rate on percent change in patty diameter during cooking for ground beef patties with soy following nine and eighteen months of storage

Evaluation time (months)	Freezing rate, hours to 0°F			
	24	48	72	96
9 months	-15.48 \pm .56b	-14.65 \pm .56b	-19.08 \pm .56a	-18.15 \pm .56a
18 months	-17.34 \pm .45a	-15.36 \pm .45b	-16.73 \pm .45ab	-15.35 \pm .45b

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 243. Effect of temperature abuse on percent change in patty diameter during cooking for ground beef patties with soy following nine months storage

Temperature Abuse	
T	N
-18.15 \pm .57a	-15.46 \pm .57b

ab Difference between means significant ($P < .05$); Mean \pm S.E. Includes only 0°F in 96 hr freezing rate; T = Temperature abused; N = Not temperature abused.

Table 244. Interaction effect of initial storage temperature and final storage temperature on percent change in patty diameter during cooking for ground beef patties with soy following nine months storage

Initial storage temperature, °F	Final storage temperature, °F	
	-10	0
-10	-17.33 \pm .28ab	-16.51 \pm .28b
0	-17.32 \pm .28ab	-18.01 \pm .28a

ab Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.

Table 245. Interaction effect of storage time (just before and after freezing) and rate of freezing on percent change in patty diameter during cooking for ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing	-16.83 ± .82ab	-16.55 ± .82ab	-14.43 ± .82b	-14.35 ± .82b
Immediately after freezing, 1 day	-15.63 ± .82ab	-16.36 ± .58ab	-16.97 ± .58ab	-18.21 ± .58a

ab Any mean comparison with the same letters is not different ($P > .05$); Mean ± S.E.

Table 247. Interaction effect of storage time (six, nine months) and freezing rate on percent change in diameter during cooking for ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
6	-16.39 ± .50bc	-16.53 ± .50bc	-17.93 ± .50ab	-16.57 ± .50bc
9	-15.48 ± .50c	-14.65 ± .50c	-19.08 ± .50a	-18.15 ± .50ab

abc Any mean comparison with different letters are different ($P < .05$); Mean ± S.E.

Table 248. Interaction effect of storage time (nine, twelve months) and rate of freezing on percent change in patty diameter during cooking for ground beef patties with soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
9	-15.48 \pm .43ef	-14.65 \pm .43f	-19.08 \pm .43a	-18.15 \pm .43ab
12	-17.16 \pm .43cd	-15.80 \pm .43e	-16.30 \pm .53de	-17.51 \pm .43bc

abcdef Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 249. Interaction effect of temperature abuse and storage time (nine, twelve months) on percent change in patty diameter during cooking for ground beef patties with soy

Evaluation time, months	Temperature abuse	
	T	N
9	18.15 \pm .46a	15.46 \pm .46b
12	17.51 \pm .46ab	17.07 \pm .46ab

ab Any mean comparison with the same letters is not different ($P > .05$); Mean \pm S.E.
T = Temperature abused; N = Not temperature abused.

Table 250. Effect of storage time (immediately following freezing, twelve months) on percent change in patty diameter during cooking for ground beef patties with soy

		12 Months storage		
		Initial storage temperature, °F =		
		-10		
Immediately following freezing, 1 day	Temperature abuse	Final storage temperature, °F =		
		-10	0	0
18.21 ± .37ab	T	17.32 ± .37ab	17.06 ± .37ab	16.85 ± .37ab
	N	17.33 ± .37ab	17.59 ± .37ab	16.17 ± .37b
				17.19 ± .37ab

ab Any mean comparison with the same letters is not different (P.>05). Mean + S.E.
T = temperature abused, N = not temperature abused. Includes only 0°F in 96 hour freezing rate.

Table 251. Effect of storage time (twelve eighteen months) on percent change in patty diameter during cooking for ground beef patties with soy

Evaluation time, months	
12	18
-17.07 \pm .28a	-15.35 \pm .28b

ab Difference between means significant ($P < .05$); Mean \pm S.E. Includes only 0°F in 96 hr freezing rate, nonabused product.

Percent moisture in raw patties did not appear in a general sense to be greatly affected by the study (Table 252). Some slight formulation differences in percent moisture did appear (higher for product used in 0°F in 24 and 72 hour rates, lower for 0°F in 48 hour rate). This trend was evident after freezing and after six, eighteen and twenty-four months of storage (Table 253). Data adjustments for the prefreezing differences in percent moisture still caused the values for the 0°F in 48 hour product to be higher (rather than lowest) in comparison to the other rates at six months (Table 254). A similar situation occurred at eighteen months of storage. For patties initially stored at -10°F, patties frozen to 0°F in 72 hours had more moisture than patties frozen to 0°F in 96 hours following nine months, while patties initially stored at 0°F, the 0°F in 72 hour rate had more moisture in raw patties than the 0°F in 48 hour rate (Table 255). Adjusting the data for prefreezing differences coupled with reanalyses eliminated many of these differences (Table 256).

Storage from six to nine months reduced moisture while storage from nine to twelve months showed an increase in moisture content (Table 257). Between eighteen and twenty-four months, percent moisture decreased especially for the 0°F in 72 hour rate (Table 258). Adjusting these data for prefreezing differences didn't eliminate storage time difference, but resulted in many of the rate effects from being different (Table 259). After twenty-four months of storage, all temperature combinations had less moisture content in patties compared to just post-freezing, except for the patties initially and finally stored at -10°F (Table 260).

Table 252. General table illustrating the percent moisture in raw ground beef patties with soy throughout various storage times and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		63.89 ± .36	61.91 ± .49	63.64 ± .15	62.63 ± .36
Immediately after freezing, 1 day		63.42 ± .26	62.21 ± .69	63.53 ± .27	62.26 ± .51
6 months	-10T	63.96 ± .64	63.52 ± .64	63.32 ± .99	62.68 ± .45
	0T	64.12 ± .59	63.04 ± .32	63.81 ± 1.01	62.55 ± .34
	20T	63.27 ± .27	63.28 ± .33	63.91 ± .71	62.79 ± .52
	20N	63.82 ± .92	62.78 ± .71	64.34 ± .55	62.76 ± .22
9 months	-10T	62.8 ± .22	61.67 ± .45	63.63 ± .49	61.55 ± .60
	-10N	---	---	---	62.03 ± .43
	0T	62.88 ± .58	62.05 ± 1.42	63.37 ± .21	62.15 ± .82
	0N	---	---	---	61.81 ± .93
12 months	-10T	63.56 ± .38	62.26 ± .44	63.26 ± .24	62.78 ± 1.03
	-10N	---	---	---	63.78 ± 1.82
	0T	63.00 ± .48	61.80 ± 1.08	63.66 ± .40	62.48 ± .53
	0N	---	---	---	62.51 ± 1.48
18 months	-10N	63.19 ± .12	62.1 ± .18	64.06 ± .28	62.66 ± .22
	0N	63.42 ± .26	61.94 ± .076	63.94 ± .24	62.44 ± .41
24 months	-10N	62.44 ± .40	61.49 ± .19	63.31 ± .59	--
	0N	62.63 ± .15	61.53 ± .42	62.90 ± .41	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 253. Effect of freezing rate on percent moisture in raw patties with soy at various storage times

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	63.9 \pm .26a	61.9 \pm .26b	63.6 \pm .26a	62.6 \pm .26ab
Immediately after freezing, 1 day	63.42 \pm .17a	62.21 \pm .17b	63.53 \pm .17a	62.26 \pm .17b
6 months	63.79 \pm .16a	63.15 \pm .16b	63.85 \pm .16a	62.70 \pm .16b
18 months	63.3 \pm .11ab	62.0 \pm .11c	64.0 \pm .11a	62.5 \pm .11bc
24 months	62.53 \pm .16ab	61.51 \pm .16b	63.10 \pm .19a	--

abc Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 254. Effect of freezing rate on percent moisture in raw ground beef patties with soy following six and eighteen months storage - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	62.92 \pm .16b	64.27 \pm .16a	63.23 \pm .16b	63.08 \pm .16b
18	62.44 \pm .11b	63.14 \pm .11ab	63.38 \pm .11a	62.93 \pm .11ab

ab Means on the same line with the same letters are not different (P>.05). Mean \pm S.E.

Table 255. Interaction effect of initial storage temperature and rate of freezing on percent moisture in raw ground beef patties with soy following nine months of storage

Initial storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	63.0 \pm .30a	62.4 \pm .30ab	63.8 \pm .30a	61.4 \pm .30b
0	62.6 \pm .30ab	61.3 \pm .30b	63.2 \pm .30a	62.3 \pm .30ab

ab Any mean comparison with different letters are different ($P < .05$);
 Mean \pm S.E.

Table 256. Interaction effect of initial storage temperature and freezing rate on percent moisture in raw ground beef patties with soy following nine months storage - data adjusted for differences prior to freezing

Initial storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	62.16 \pm .30ab	63.51 \pm .30a	63.14 \pm .30ab	61.77 \pm .30b
0	61.78 \pm .30b	62.45 \pm .30ab	62.62 \pm .30ab	62.69 \pm .30ab

ab Any mean comparison with the same letters is not different ($P>.05$).

Mean \pm S.E.

Table 257. Effect of various storage time comparisons on percent moisture in raw ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	24 months
62.5 \pm .12a	62.3 \pm .12b
6 months	9 months
63.4 \pm .12a	62.5 \pm .12b
9 months	12 months
61.9 \pm .25b	62.9 \pm .25a

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

Table 258. Interaction effect of storage time (eighteen, twenty-four months) and rate of freezing on percent moisture in raw ground beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	63.31 \pm .082b	62.02 \pm .082d	64.00 \pm .082a
24	62.54 \pm .082c	61.51 \pm .082e	62.92 \pm .12bc

abcde Any mean comparisons with different letters are different ($P < .05$); Mean \pm S.E.

Table 259. Interaction effect of storage time (eighteen, twenty-four months) and rate of freezing on percent moisture in raw ground beef patties with soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
18	62.44 \pm .082b	63.14 \pm .082a	63.38 \pm .082a
24	61.66 \pm .082c	62.63 \pm .082b	62.30 \pm .082b

abc Any mean comparison with different letters is different ($P > .05$).
Mean \pm S.E.

Table 260. Effect of storage time (immediately following freezing, twenty-four months) on percent moisture in raw ground beef patties with soy

		24 months storage	
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10	0
	Final Storage temperature, °F =	-10	0
63.06 ± .13a		62.5 ± .16ab 62.3 ± .13b	62.28 ± .13b 62.37 ± .16b

ab Means on the same line with different letters are different ($P < .05$); Mean ± S.E.

As would be expected, percent fat in raw patties reflect the reciprocal of percent moisture in raw patties; slightly higher for 0°F in 48 hour rate product and slightly lower for 0°F in 72 hour rate product (Table 261). After most storage times, 0°F in 48 and 96 hour patties had more fat than 0°F in 24 and 72 hour rate patties (Table 262). Adjusting the data for prefreezing differences eliminated most of the rate effects except for six months (Table 263). Fat levels at nine months were similar between 0°F in 24 and 48 hour patties if initial storage was at -10°F, but were higher for the 0°F in 48 hour product if storage was at 0°F (Table 264). Adjusting these results for prefreezing differences in the formulations removed many of these effects (Table 265). Patties stored for nine months possessed more fat than patties stored for six months (Table 266).

To some degree, formulations that had the highest (0°F in 24 and 72 hours) and lowest (0°F in 48 and 96 hours) moisture levels in the raw state also had the highest and lowest levels in the cooked state (Table 267). After both six and nine months of storage, -10°F produced more moisture in cooked patties than 0°F (Table 268). At six months, 0°F final storage resulted in higher moisture in patties than +20°F storage (Table 269). Again, at nine months, the colder (-10°F) final storage temperature produced more moisture in cooked patties (Table 270). Following twelve months of storage, 0°F in 24 hour freezing rate exhibited more moisture in cooked patties than the 0°F in 96 hour rate. Compared to the 0°F in 24 and 72 hour rates, 0°F in 48 hours showed less moisture in cooked patties at twenty-four months (Table 271).

Table 261. General table illustrating the percent fat in raw ground beef patties with soy throughout storage times and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F				
		24	48	72	96	
Before freezing		17.59 ± .52	19.60 ± .65	17.94 ± .25	19.02 ± .44	
Immediately after freezing, 1 day		18.15 ± .15	19.32 ± .83	17.65 ± .37	19.25 ± .49	
6 months	-10T	17.85 ± .65	18.92 ± .61	17.98 ± 1.23	19.10 ± .62	
	OT	17.67 ± .41	19.29 ± .43	17.96 ± .88	19.27 ± .33	
	20T	18.54 ± .75	19.03 ± .26	17.64 ± .62	19.01 ± .43	
	20N	17.73 ± .80	19.08 ± .40	17.63 ± .43	19.36 ± .15	
9 months	-10T	18.34 ± .39	19.98 ± .33	17.72 ± .29	20.19 ± .50	
	-10N	--	--	--	19.31 ± .52	
	OT	18.13 ± .45	19.57 ± 1.16	17.99 ± .23	19.62 ± .69	
	ON	--	--	--	19.33 ± .81	
12 months	-10T	20.24 ± .44	19.13 ± .29	18.21 ± .20	18.91 ± 1.97	
	-10N	--	--	--	18.21 ± .87	
	OT	18.43 ± .46	19.36 ± .89	17.83 ± .28	19.29 ± 1.30	
	ON	--	--	--	19.30 ± .45	
18 months	-10N	17.96 ± .30	19.81 ± .13	17.92 ± .36	20.07 ± 1.71	
	ON	18.22 ± .19	19.79 ± .27	17.66 ± .31	19.42 ± .28	
24 months	-10N	18.25 ± .25	19.92 ± .32	18.10 ± .42	--	
	ON	18.19 ± .23	19.76 ± .44	18.31 ± .19	--	

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 262. Effect of freezing rate on percent fat in raw ground beef patties with soy following various storage times

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	17.59 \pm .34b	19.6 \pm .34a	17.94 \pm .34ab	19.02 \pm .34ab
Immediately after freezing, 1 day	18.15 \pm .18ab	19.32 \pm .18a	17.65 \pm .18b	19.25 \pm .18a
6 months	17.95 \pm .15b	19.08 \pm .15a	17.8 \pm .15b	19.19 \pm .15a
18 months	18.09 \pm .23b	19.80 \pm .23a	17.79 \pm .23b	19.74 \pm .23a
24 months	18.19 \pm .12b	19.84 \pm .12a	18.21 \pm .16b	--

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 263. Effect of freezing rate on percent fat in raw ground beef patties with soy following six months storage - data adjusted for differences prior to freezing

Freezing rate, hours to 0 °F			
24	48	72	96
18.89 \pm .15a	18.02 \pm .15b	18.39 \pm .15ab	18.71 \pm .15a

ab Means on the same line with the same letters are not different (P>.05). Mean \pm S.E.

Table 264. Interaction effect of initial storage temperature and rate of freezing on percent fat in raw ground beef patties with soy following nine months of storage

Initial storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	18.17 \pm .24bc	19.31 \pm .24ab	17.72 \pm .24c	20.24 \pm .24a
0	18.31 \pm .24bc	20.25 \pm .24a	17.99 \pm .24c	19.57 \pm .24a

abc Any mean comparisons with different letters are different ($P < .05$);
Mean \pm S.E.

Table 265. Interaction effect of initial storage temperature and freezing rate on percent fat in raw ground beef patties with soy following nine months storage - data adjusted for differences prior to freezing

Initial storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	19.11 \pm .24ab	18.25 \pm .24b	18.31 \pm .24b	19.76 \pm .24a
0	19.25 \pm .24ab	19.19 \pm .24ab	18.58 \pm .24ab	19.09 \pm .24ab

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E.

Table 266. Effect of storage time (six, nine months) on percent fat in raw ground beef patties with soy

Evaluation time, months	
6	9
18.51 \pm .11b	18.94 \pm .11a

ab Difference between means significant ($P < .05$);
Mean \pm S.E.

Table 267. General table illustrating the percent moisture in cooked beef patties with soy throughout storage according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		57.34 ± .35	55.52 ± 1.00	55.43 ± .54	55.71 ± .18
Immediately after freezing, 1 day		53.55 ± .66	54.04 ± .24	54.37 ± .98	52.72 ± .56
6 months	-10T	52.96 ± .45	51.86 ± .61	52.95 ± 1.13	51.54 ± .79
	0T	53.43 ± .89	52.17 ± 1.33	53.26 ± 1.00	52.03 ± 1.22
	20T	52.06 ± .46	51.35 ± 1.08	52.04 ± 1.46	51.26 ± .96
	20N	53.03 ± .98	51.56 ± .92	51.74 ± .83	51.07 ± .87
9 months	-10T	52.89 ± .28	53.0 ± 1.13	52.23 ± .67	51.28 ± .51
	-10N	--	--	--	51.15 ± .71
	0T	52.41 ± .77	51.48 ± 1.11	52.24 ± 1.33	50.76 ± .71
	0N	--	--	--	50.89 ± .43
12 months	-10T	53.16 ± .43	52.17 ± .59	52.22 ± 1.32	51.27 ± .61
	-10N	--	--	--	51.63 ± .76
	0T	53.02 ± .62	52.08 ± .82	52.34 ± .67	51.62 ± .60
	0N	--	--	--	52.07 ± .43
18 months	-10N	54.14 ± .31	52.8 ± .65	53.2 ± .53	51.87 ± .78
	0N	53.31 ± .72	52.11 ± .60	53.83 ± .85	51.45 ± .36
24 months	-10N	52.90 ± .43	52.16 ± .58	52.90 ± .24	--
	0N	52.95 ± .61	51.95 ± .17	52.33 ± .51	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 268. Effect of initial storage temperature with storage times on percent moisture in cooked beef patties with soy

Evaluation time, months	Initial storage temperature, 0°F	
	-10	0
6	52.43 \pm .16a	51.86 \pm .16b
12	52.0 \pm .15a	51.29 \pm .15b

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 269. Effect of final storage temperature on percent moisture in cooked beef patties with soy following six months storage

Temperature abuse	Final storage temperature, °F		
	-10	0	20
T	52.33 \pm .23ab	52.72 \pm .23a	51.68 \pm .23b
N	--	--	51.85 \pm .23ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused.

Table 270. Effect of final storage temperature on percent moisture in cooked beef patties with soy following nine months storage

Final storage temperature, 0°F	
-10	0
52.35 + <u>.18</u> a	51.72 + <u>.18</u> b

ab Difference between means significant ($P < .05$);
Mean + S.E.

Table 271. Effect of freezing rate on percent moisture in cooked beef patties with soy at various storage times

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	53.09 \pm .27a	52.12 \pm .27ab	52.28 \pm .31ab	51.45 \pm .27b
24	52.93 \pm .14a	52.05 \pm .14b	52.62 \pm .14a	--

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

Storage time comparisons, especially with values obtained just after freezing created less moisture in cooked patties (Table 272). Freezing produced reductions in cooked moisture values for the 0°F in 24 and 96 hour rates, but not the 0°F in 72 and 96 hour rates (Table 273). Patties initially stored at 0°F and finally stored at +20°F following six months storage displayed lower moisture in cooked form than patties tested just after freezing (Table 274). Between six and nine months, cooked moisture values decreased only if the initial storage temperature was -10°F (Table 275). The same situation occurred if the final storage temperature was 0°F (Table 276). An interaction of storage time (nine, twelve months) initial and final temperatures was detected (Table 277), but the values followed no logical pattern. After twelve months storage, regardless of temperature of no abuse, patties initially stored at 0°F and finally at -10°F had less moisture in cooked form than patties immediately evaluated after freezing (Table 278). There were indications of a slight decline in percent moisture between twelve and eighteen months if patties were finally stored at 0°F (Table 279). Between just post-freezing and twenty-four months of storage, moisture content in cooked patties did not decline if frozen to 0°F in 24 hours (Table 280). However, most initial-final temperature combinations for the 0°F in 48 hour rate generated reductions in moisture level of cooked patties.

The general data pertaining to percent fat in cooked patties is illustrated in Table 281. As would somewhat be expected from the cooked patty moisture data, percent fat was slightly lower in patties frozen to 0°F in 24 hours and slightly higher in patties frozen to 0°F in 96 hours (Table 281). This trend respective to freezing rate was noted immediately

Table 272. Effects of various storage time comparisons on percent moisture in cooked beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	6 months
53.67 \pm .20a	52.52 \pm .20b
Immediately following freezing, 1 day	9 months
53.67 \pm .21a	52.04 \pm .21b
Immediately following freezing, 1 day	12 months
53.67 \pm .21a	51.85 \pm .21b
Immediately following freezing, 1 day	18 months
53.67 \pm .21a	51.66 \pm .19b
18 months	24 months
53.23 \pm .10a	52.57 \pm .12b

ab Differences between means on the same line are significant ($P < .05$);
mean \pm S.E.

Table 273. Interaction effect of storage time (before freezing, immediately following freezing) and freezing rate on percent moisture in cooked beef patties with soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	57.34 \pm .46a	55.52 \pm .46abc	55.43 \pm .46abc	55.71 \pm .46ab
Immediately after freezing, 1 day	53.58 \pm .46cd	54.04 \pm .32bcd	54.37 \pm .32bcd	52.72 \pm .32d

abcd Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 274. Effect of storage time (immediately following freezing, six months) on percent moisture in cooked beef patties with soy

		6 months storage					
Immediately following freezing, 1 day	Temperature abuse	Initial Storage temperature, °F =		Final Storage temperature, °F =			
		-10		0		20	
53.67. + .31a	T	52.74 + .31ab	53.04 + .31a	52.01 + .31ab	51.91 + .31ab	52.4 + .31ab	51.35 + .31a
	N	--	--	51.92 + .31ab	--	--	51.78 + .31

ab Any mean comparison with the same letters are not different ($P > .05$); Mean + S.E.; T = Temperature abused; N = Not temperature abused.

Table 275. Interaction effect of storage time (six, nine months) and initial storage temperature on percent moisture in cooked beef patties with soy

Evaluation time, months	Initial storage temperature, 0°F	
	-10	0
6	52.89 \pm .17a	52.16 \pm .17b
9	51.86 \pm .17b	52.21 \pm .17ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.

Table 276. Interaction effect of storage time (six, nine months) and final storage temperature on percent moisture in cooked beef patties with soy

Evaluation time, months	Final storage temperature, 0°F	
	-10	0
6	52.33 \pm .17ab	52.72 \pm .17a
9	52.35 \pm .17ab	51.72 \pm .17b

ab Any mean comparisons with the same letters are not different ($P > .05$); Mean \pm S.E.

Table 277. Interaction effect of storage time (nine, twelve months), final storage temperature and initial storage temperature on percent moisture in cooked beef patties with soy

Evaluation time, months	Final storage temperature, °F	Initial storage temperature, °F	
		-10	0
9	-10	51.12 \pm .22 ab	51.32 \pm .22 ab
	0	51.11 \pm .22 ab	50.55 \pm .22 b
12	-10	51.99 \pm .22 a	50.91 \pm .22 ab
	0	52.02 \pm .22 a	51.68 \pm .22 ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.

Table 278. Effect of storage time (immediately following freezing, twelve months) on percent moisture in cooked ground beef patties with soy

		12 Months storage	
		Initial storage temperature, °F =	
		-10	
Immediately following freezing, 1 day	Temperature abuse	Final storage temperature, °F =	
		-10	
		0	0
52.72 ± .29a	T	51.76 ± .29ab	52.00 ± .29ab
	N	52.22 ± .29ab	52.03 ± .29ab
		51.03 ± .29b	52.11 ± .29ab
		0	0

ab Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E.
 T = temperature abused, N = not temperature abused. Includes only 0°F in 96 hour freezing rate.

Table 279. Interaction effect of storage time (twelve, eighteen months) and final storage temperature on percent moisture in cooked beef patties with soy^a

Evaluation time, months	Final storage temperature, 0°F	
	-10	0
12	51.63 \pm .14	52.07 \pm .14
18	51.87 \pm .14	51.45 \pm .14

^aInteraction significant ($P < .05$) by analyses of variance, but not HSD. Mean \pm S.E.

Table 280. Interaction effect of storage time (immediately following freezing, twenty-four months) initial storage temperature, final storage temperature and rate of freezing on percent moisture in cooked beef patties with soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately after freezing, 1 day			53.55 ± .29ab	54.04 ± .29a	54.37 ± .29a
24 months	-10	-10	52.53 ± .29ab	52.49 ± .29ab	52.78 ± .44ab
		0	53.28 ± .29ab	51.92 ± .29b	51.86 ± .29b
	0	-10	53.27 ± .29ab	51.83 ± .29b	53.06 ± .29ab
		0	52.62 ± .29ab	51.99 ± .29b	52.85 ± .44ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean ± S.E.

Table 281. General table illustrating the percent fat in cooked beef patties with soy throughout storage times and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation Time	Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
		24	48	72	96
Before freezing		15.78 ± .11	17.29 ± 1.28	17.14 ± .35	17.69 ± .14
Immediately after freezing, 1 day 6 months	-10 T	18.32 ± .50	17.67 ± .41	17.0 ± .23	18.73 ± .22
	0 T	18.08 ± .38	18.81 ± .81	18.28 ± .78	19.63 ± .86
	20 T	17.56 ± .64	18.38 ± .91	17.33 ± .26	19.38 ± .48
	20 N	19.04 ± .68	19.58 ± .61	18.67 ± .37	20.21 ± .65
9 months	-10 T	17.82 ± .53	18.93 ± .51	18.54 ± .69	20.02 ± .62
	-10 N	17.99 ± .28	18.69 ± .65	17.94 ± .88	19.79 ± .30
	0 T	--	--	--	19.97 ± .61
	0 N	18.37 ± .72	19.17 ± .55	17.98 ± .41	20.43 ± .25
12 months	-10 T	--	--	--	20.1 ± .31
	-10 N	18.43 ± .28	19.08 ± .22	19.49 ± 1.19	19.5 ± .28
	0 T	--	--	--	20.04 ± .68
	0 N	18.3 ± .26	19.08 ± .70	18.8 ± .59	19.14 ± .24
18 months	-10 T	--	--	--	19.73 ± .14
	-10 N	17.48 ± .32	18.54 ± .49	18.51 ± 1.16	19.32 ± .60
	0 T	17.68 ± .50	18.71 ± .68	18.08 ± .24	19.72 ± .26
	0 N	--	--	--	--
24 months	-10 T	18.03 ± .29	18.78 ± .20	18.51 ± .23	--
	-10 N	18.02 ± .52	18.94 ± .38	18.54 ± .45	--
	0 T	--	--	--	--
	0 N	--	--	--	--

^aMean ± S.D. T = temperature abused, N = not temperature abused.

following freezing and after six, eighteen and twenty-four months of storage (Table 282). An interaction ($P < .05$) for freezing rate and evaluation just before and after freezing was noted for percent fat (Table 283). For some reason, fat values for 0°F in 24 hour frozen patties were much less before vs after freezing. This did not occur for the other rates. At six months, product initially held at -10°F had slightly less fat than patties held at 0°F (Table 284). Following six months of storage, $+20^{\circ}\text{F}$ stored product had more fat than patties held at 0°F (Table 285). At nine months of storage, more fat was noted in cooked patties from the 0°F in 96 hour rate, but mainly if they were initially stored at 0°F (Table 286). After twelve months of storage, for patties initially stored at 0°F , those finally stored at -10°F had more fat in cooked product than those stored at 0°F (Table 287). Nonabused product had slightly more fat following twelve months than abused product (Table 288).

Six, nine and twelve month comparisons with immediately post-freezing showed increases in percent fat in cooked patties (Table 289). Several of the temperature combinations (especially those including $+20^{\circ}\text{F}$ final storage temperature produced more fat in cooked patties at six months than what was noted immediately post-freezing (Table 290). Nine months of storage produced an increase in cooked fat over six months for patties held at -10°F initial temperature, but not at 0°F initial temperature (Table 291). Also, for patties held finally at 0°F , an increase in fat occurred between six and nine months; this did not occur for patties finally stored at -10°F (Table 292). At nine months of storage, some of the initial-final temperature combinations showed increases in cooked fat content (probably due to decreases in moisture during storage) for both the 0°F in 48 and 96

Table 282. Effect of freezing rate on percent fat in cooked beef patties with soy following various storage times

Evaluation Time	Freezing Rate, hours to 0°F			
	24	48	72	96
Immediately after freezing, 1 day	18.32 ± .19ab	17.67 ± .19ab	17.00 ± .19b	18.73 ± .19a
6 months	18.12 ± .14c	18.92 ± .14b	18.21 ± .14c	19.81 ± .14a
18 months	17.58 ± .23c	18.62 ± .23ab	18.3 ± .23bc	19.52 ± .23a
24 months	18.03 ± .13b	18.86 ± .13a	18.52 ± .18ab	--

abc Means on the same line with different letters are different ($P < .05$); Mean ± S.E.

Table 283. Interaction effect of storage time (before freezing, immediately following freezing) on percent fat in cooked beef patties with soy

Evaluation Time	Freezing Rate, hours to 0°F		
	24	48	72
Before freezing	15.78 ± .32c	17.29 ± .32ab	17.14 ± .32bc
Immediately after freezing, 1 day	18.32 ± .32ab	17.67 ± .23ab	17.00 ± .23bc
			18.73 ± .23a

abc Any mean comparison with the same letters is not different ($P > .05$); Mean ± S.E.

Table 284. Effect of initial storage temperature on percent fat in cooked beef patties with soy following six months storage

<u>Initial Storage Temperature, °F</u>	
<u>-10</u>	<u>0</u>
18.58 \pm .103b	18.95 \pm .103a

ab Difference between means are significant ($P < .05$). Mean \pm S.E.

Table 285. Effect of final storage temperature on percent fat in cooked patties with soy following six months storage

Temperature Abuse	Final Storage Temperature, °F		
	-10	0	20
T	18.70 \pm .14bc	18.16 \pm .14c	19.38 \pm .14a
N	--	--	18.83 \pm .14ab

abc Any mean comparison with different letters is different ($P < .05$).
 Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 286. Interaction effect of initial storage temperature, final storage temperature and rate of freezing on percent fat in cooked beef patties with soy following nine months storage

Initial Storage Temperature, °F	Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
		24	48	72	96
-10	-10	17.78 + .29de	19.19 + .29abcd	18.51 + .29bcde	20.03 + .29ab
	0	18.82 ± .29abcde	19.40 ± .29abcd	17.81 ± .29de	20.38 ± .29a
0	-10	18.21 + .29cde	18.18 + .29cde	17.36 + .29e	19.55 + .29abc
	0	17.92 ± .29cde	18.94 ± .29abcde	18.15 ± .29cde	20.48 ± .29a

abcde Any mean comparisons with the same letters are not different ($P > .05$); Mean ± S.E.

Table 227. Interaction effect of final storage temperature and initial storage temperature on percent fat in cooked beef patties with soy following twelve months of storage

Final Storage Temperature, °F	Initial Storage Temperature, °F	
	-10	0
-10	19.44 \pm .15ab	20.1 \pm .15a
0	19.47 \pm .15ab	19.1 \pm .15b

ab Any mean comparisons with the same letters are not different ($P > .05$).
 Mean \pm S.E. Includes only 0°F in 96-hour freezing rate.

Table 288. Effect of temperature abuse on percent fat in cooked beef patties with soy following twelve months storage

<u>Temperature Abuse</u>	
<u>T</u>	<u>N</u>
19.32 \pm .104b	19.88 \pm .104a

ab Difference between means significant ($P < .05$). Means \pm S.E.

Table 289. Effect of various storage time comparisons on percent fat in cooked beef patties with soy

<u>Evaluation time comparisons</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
17.93 \pm .12b	18.75 \pm .12a
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
18.72 \pm .28b	20.13 \pm .28a
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
17.93 \pm .16b	18.99 \pm .16a

ab Difference between means significant ($P < .05$); Mean \pm S.E.

Table 290. Effect of storage time (immediately following freezing, six months) on percent fat in cooked beef patties with soy

		6 Months Storage				
Immediately following freezing, 1 day	Abuse	Initial storage temperature, °F =		Final storage temperature, °F =		
		-10		-10	0	20
17.93 ± .2d	T	18.42 ± .2bcd	18.03 ± .2cd	19.13 ± .2a	18.98 ± .2a	18.3 ± .2bcd
	N	--	--	18.74 ± .2abcd	--	--
						19.62 ± .2a
						18.91 ± .2abc

abcd Any mean comparisons with different letters are different (P<.05). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 291. Interaction effect of storage time and final storage temperature on percent fat in cooked beef patties with soy

Evaluation Time, months	Initial Storage Temperature, °F	
	-10	0
6	18.22 \pm .15b	18.64 \pm .15b
9	18.99 \pm .15a	18.60 \pm .15b

ab Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 292. Interaction effect of storage time (six, nine months) and final storage temperature on percent fat in cooked beef patties with soy

Evaluation Time, months	Final Storage Temperature, °F	
	-10	0
6	18.7 \pm .15ab	18.16 \pm .15b
9	18.6 \pm .15ab	18.99 \pm .15a

ab Any mean comparison with the same letters is not different ($P > .05$). Mean \pm S.E.

hour rates (Table 293). Patties stored at 0°F, both initially and finally, possessed an increase in cooked fat content at nine months over that noted immediately following freezing (Table 294). Between nine and twelve months, cooked fat increased only in the 0°F in 72 hour rate (Table 295) while decreasing only in the 0°F final storage temperature (Table 296). Temperature abused product decreased in cooked fat percentage between nine and twelve months, while nonabused patties underwent no change (Table 297). At twelve months of storage, all initial and final temperature combinations exhibited an increase in cooked fat content compared to just post-freezing with the exception of 0°F initial and final temperature (Table 298). Nonabused patties initially stored at 0°F and finally stored at -10°F had more cooked fat than patties evaluated just after freezing (Table 299). At twenty-four months, the only treatment combination to differ (higher) in contrast to just post-freezing was -10°F initial and 0°F final temperature (Table 300).

Values for general data on expressible moisture are presented in Table 301. The values carry no quantitative meaning, but the larger the number the higher the expressible moisture. Values were somewhat variable but were generally lowest for the 0°F in 96 hour rate. Higher values for the 0°F in 24 and 48 hour rates, in contrast to 0°F in 72 and 96 hour rates, were observed after six months storage (Table 302). Between just post-freezing and eighteen months of storage, expressible moisture increased, while six vs nine and eighteen vs twenty-four months storage showed lower expressible moisture with storage (Table 303). Following eighteen months of storage, just the 0°F initial and final storage temperature combination produced higher expressible moisture to that found just after freezing (Table 304).

Table 293. Interaction effect of storage time (immediately following freezing, nine months) initial storage temperature, final storage temperature and rate of freezing on percent fat in cooked beef patties with soy

Evaluation Time	Initial Storage Temperature, °F	Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
			24	48	72	96
Immediately after freezing, 1 day						
			18.32 ± .27defgh	17.67 ± .27fgh	17.00 ± .27h	18.73 ± .27cdefy
9 months	-10	-10	17.78 ± .27fgh	19.19 ± .27abcdef	18.51 ± .27defgh	20.03 ± .27abc
		0	18.81 ± .27bcdefg	19.40 ± .27abcde	17.81 ± .27bcdefy	20.38 ± .27ab
	0	-10	18.21 ± .27defgh	18.18 ± .27defgh	17.36 ± .27gh	19.55 ± .27abcd
		0	17.92 ± .27efgh	18.94 ± .27abcdefg	18.15 ± .27defgh	20.48 ± .27a

abcdefgh Any mean comparison with different letters is different ($P < .05$). Mean ± S.E.

Table 294. Effect of storage time (immediately following freezing, nine months) on percent fat in cooked beef patties with soy

		9 Months Storage			
Immediately following freezing, 1 day	Abuse	Initial storage temperature, °F =		0	
		Final storage temperature, °F =		-10	
18.73 ± .27b	T	20.03 ± .27ab	20.38 ± .27a	19.55 ± .27ab	20.49 ± .27a
	N	19.71 ± .27ab	19.91 ± .27ab	20.23 ± .27ab	20.28 ± .27a

ab Any mean comparisons with the same letters are not different ($P > .05$). Mean ± S.E.
T = temperature abused, N = not temperature abused.

Table 296. Effect of storage time (nine, twelve months) and final storage temperature on percent fat in cooked beef patties with soy

Evaluation Time, months	Final Storage Temperature, °F	
	-10	0
9	19.88 \pm .13ab	20.26 \pm .13a
12	19.77 \pm .13ab	19.43 \pm .13b

ab Any mean comparisons with the same letter are not different ($P > .05$).
Mean \pm S.E.

Table 297. Interaction effect of storage time (nine, twelve months) and temperature abuse on percent fat in cooked beef patties with soy

Evaluation Time, months	Temperature Abuse	
	T	N
9	20.11 \pm .13a	20.03 \pm .13a
12	19.32 \pm .13b	19.88 \pm .13ab

ab Any mean comparisons with different letters are different ($P < .05$).
Means \pm S.E. T = temperature abused, N = not temperature abused.

Table 298. Effect of storage time (immediately following freezing, twelve months) on percent fat in cooked beef patties with soy

		12 Months Storage	
Immediately following freezing, 1 day	Initial storage temperature, °F =	-10	0
	Final storage temperature, °F =	-10	0
17.93 ± .21b	19.17 ± .21a	19.03 ± .24a	18.62 ± .21ab

ab Means on the same line with the same letter are not different ($P > .05$). Mean ± S.E.

Table 299. Effect of storage time (immediately following freezing, twelve months) on percent fat in cooked ground beef patties with soy

		12 Months storage		
		Initial storage temperature, °F =		
		-10	0	
Immediately following freezing, 1 day	Temperature abuse	Final storage temperature, °F =		
		-10	0	0
18.73 ± .19b	T	19.37 ± .19b	19.19 ± .19b	19.63 ± .19ab
	N	19.50 ± .19ab	19.75 ± .19ab	20.57 ± .19a
				19.09 ± .19b
				19.71 ± .19ab

ab Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E.
T = temperature abused, N = not temperature abused. Includes only 0°F in 96 hours freezing rate.

Table 300. Interaction effect of storage time (immediately following freezing, twenty-four months) initial storage temperature, final storage temperature and freezing rate on percent fat in cooked beef patties with soy

Evaluation Time	Initial Storage Temperature, °F	Final Storage Temperature, °F	Freezing Rate, hours to 0°		
			24	48	72
Immediately after freezing, 1 day			18.32 + .24ab	17.67 + .24ab	17.00 + .24b
24 months	-10	-10	18.13 + .24ab	18.62 + .24a	18.55 + .24ab
		0	17.73 + .24ab	19.24 + .24a	18.88 + .24a
	0	-10	17.92 + .24ab	18.95 + .24a	18.44 + .24ab
		0	18.32 + .24ab	18.64 + .24a	18.16 + .24ab

ab Any mean comparison with the same letters is not different ($P > .05$). Mean + S.E.

Table 301. General table illustrating the expressible moisture in raw ground beef patties with soy throughout storage times and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		.014 ± .00093	.013 ± .0014	.014 ± .00064	.012 ± .00062
Immediately after freezing, 1 day		.013 ± .00065	.015 ± .0015	.013 ± .0017	.012 ± .0018
6 months	-10T	.014 ± .0013	.014 ± .0012	.014 ± .0021	.013 ± .0014
	0T	.014 ± .0012	.015 ± .0014	.014 ± .0016	.013 ± .0015
	+20T	.015 ± .0021	.015 ± .0013	.013 ± .0015	.014 ± .001
	+20N	.014 ± .0017	.015 ± .0019	.013 ± .0011	.014 ± .0016
9 months	-10T	.012 ± .0014	.013 ± .0018	.013 ± .0012	.013 ± .0012
	-10N	--	--	--	.013 ± .0017
	0T	.012 ± .0016	.012 ± .0017	.013 ± .001	.012 ± .0014
	0N	--	--	--	.012 ± .0016
12 months	-10T	.013 ± .0014	.011 ± .0014	.012 ± .0019	.011 ± .0011
	-10N	--	--	--	.012 ± .0016
	0T	.012 ± .00085	.011 ± .0013	.012 ± .0022	.011 ± .0018
	0N	--	--	--	.012 ± .0016
18 months	-10N	.015 ± .002	.016 ± .0014	.014 ± .002	.014 ± .00098
	0N	.016 ± .0014	.016 ± .0017	.016 ± .0015	.014 ± .0012
24 months	-10N	.013 ± .0013	.011 ± .0016	.012 ± .0015	--
	0N	.013 ± .0012	.012 ± .0019	.012 ± .00098	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 302. Effect of freezing rate on expressible moisture in raw ground beef patties with soy at various storage times

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	.014 \pm .00025 ab	.015 \pm .00025 a	.014 \pm .00025 b	.014 \pm .00025 b
24 ^C	.013 \pm .00039	.012 \pm .00039	.012 \pm .00039	--

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

^CDifference due to freezing rate significant due to analysis of variance, but not by HSD test.

Table 303. Effect of various storage time comparisons on expressible moisture in raw ground beef patties with soy

Evaluation times	
Immediately following freezing, 1 day	18 months
.013 \pm .00014b	.015 \pm .00014a
6 months	9 months
.014 \pm .00016a	.013 \pm .00016b
18 months	24 months
.015 \pm .00026a	.012 \pm .0003b

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

Table 304. Effect of storage time (immediately following freezing, eighteen months) on expressible moisture in raw ground beef patties with soy

		18 months storage	
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10	0
	Final Storage temperature, °F =	-10	0
.0132 ± .0004b		.0149 ± .0004ab	.0148 ± .0004ab
			.0145 ± .0004ab
			.0157 ± .0004a

ab Means on the same line with the same letters are not different ($P > .05$); Mean ± S.E.

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